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WHAT CONTRIBUTIONS TO MATHEMATICS INSTRUCTION CAN WE EXPECT IN THE LAST ONE HALF OF THE TWENTIETH CENTURY?*

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I envy Dr. Breslich in his present position. He has just given us a splendid résumé of the contributions of mathematics and their effect over the first half of this century.[1] Dr. Breslich has played no small part in contributing to this progress. He not only had the vision but he formulated the plans and then executed them. Being a firm believer in the value of the historical approach in the interpretation of the future, I feel that Dr. Breslich should continue with my share of this program. He no doubt sees a set of vectors whose directions are well known to him. But as for me, I stand in the center of these same vectors and know not which way they are directed. Perhaps at the close of this meeting you will want to discuss the subject of my talk with him to determine precisely what contributions we may expect.

May I take this opportunity to publicly express my appreciation and that of my colleagues to Dr. Breslich and his contemporaries for all the help and inspiration they have given to us, and to mathematics instruction during the half century just closing.

At best, prediction is a dangerous thing because in most cases it involves so many variables. These variables are combined in such a delicate configuration that a critical combination may be reached by one small change in any one of them. The mere fact that we discuss

* Read before the Mathematics Section of the C.A.S.M.T. at its "Golden Anniversary" Convention in Chicago, November 24, 1950.

[1] See February 1951, page 131.

possible changes may nullify what might have transpired had no discussion taken place. The progress of the world hangs on a precision balance and any small disturbance may set up reactions which lead to enormous final changes in the world. It is true the world's activity goes forward as the result of the inductive processes. However, the very nature of inductive thinking makes it susceptible to sudden unforeseen changes at certain points along the way. These changes, which do not appear on the first observation, often divert the whole course of events. By disseminating our observations and thoughts on the subject we may cause conditions to come about that would not have happened without these suggestions. Oftentimes I have wondered if the present picture in mathematics would have been altered had Dr. E. H. Moore not had the courage to make his memorable speech on December 29, 1902. There was a great deal of shaking of heads and dissenting opinion on that day but the very fact the opposition was there may have affected the whole future course of mathematics. As an interesting side light, during that same address Dr. Moore commented on the meeting in November of the Central Association of Physics Teachers here in Chicago. He was interested in their proposal to expand and take in other areas. He goes on to say he believes this expansion will come about. As we look at the Central Association of Science and Mathematics Teachers of today, the truth of his words is evident. We see all the fields of science and mathematics from elementary through the university working for a common good in one great unified organization.

There are two approaches from which we might choose in taking our look into the future. The first is, what contributions can we rightfully expect, and the second, what contributions should we hope for if all our desires could be fulfilled? I shall not attempt to distinguish between the two because our desires and our judgments go hand in hand. We can set our sights and continue to reach, even though Utopia is never found.

First among the conditions which affect what contributions there shall be, is the fact that mathematics is not a static thing. It is dynamic and growing every day in many ways. Many years ago I wrote a paper for one of my college professors, trying to leave the impression with him that the field of mathematics was just opening up. My grade on the paper was not one to be proud of, and the old gentleman penned a little note on my paper to the effect that the only changes to expect in mathematics would be those of degree on the then established content; there were no new fields to conquer. But now we see the vast changes which have taken place in the field of mathematics. Look at the fields of topology, modern algebra, affine geometry, fields and rings, all group theory and even non-Euclidean

geometry is coming to the fore as an integral part of our culture. The end is not yet in sight. As you read the mathematics journals you see that new approaches to all problems and extensions of our present knowledge are appearing every day.

This enormous increase of mathematical information demands a careful selection if we are to separate the part which is pertinent to our culture from that which has little bearing on progress. In the next half century we will see much careful analysis of existing content. After this analysis there will be a great deal of the present mathematics content stored in the archives. This material at one time was of great value and it is still of interest but it cannot now compete with other items which have been developed and have both greater interest and value. We can get a better picture of why some content need not be kept in the active file by looking at the thesis topics for graduates of Yale back in the early 1700's. Here are a few:

1. The surface of a sphere is four times the area of its greatest circle.
2. The angle at the base of a horizontal sundial must agree with the elevation of the pole.
3. What is evolved in involution is resolved by evolution.
4. Multiplication by a decimal fraction decreases the value of any number and division increases it.

Such material is now common knowledge of most grade school pupils. All that has transpired between now and then cannot be comprehended and used by one man in his lifetime. If Euclid were to attempt today to gather in one book all the elements, his working years would have to approach those of Methuselah.

What are some of the things we will send back to the archives because we are unable to have the satisfaction of mastering the entire field? Many theorems of geometry which we now prove will be stored away, some may be taken as common notions and some few may take the place of original problems for the student's perusal. We are already well along the way in this area. Much of factoring will be sent to the archives to be picked out for rainy day entertainment. The radical will be replaced by the more efficient logarithms or perhaps the table. Many trigonometric identities will take their place beside factoring, but those that remain will become a more vital factor in our progress. These remaining identities will be used to a much greater degree because of their adaptability in the operation of series and complex numbers. Elaborate simultaneous equations will be left to gather dust. Much of the drill material with the complicated polynomials will be dropped by the wayside. Common fractions, except those which have been our common heritage, will be replaced by the more efficient decimal system.

The very fact that we have so much available material enables us to develop at a more rapid rate. Therefore, one of the distinguishing characteristics will be a more efficient use of this large body of information at our command. All of you have been requested to solve problems by some particular method when your better judgment told you that a solution by a different method would be more expedient. A teacher I observed the other day gave her students the opportunity to prove the theorem of Pythagoras by any method they chose. Those with ability and judgment were able to select material which enabled them to give the proof in about four lines. More and more we can expect students of mathematics to be in a position to choose wisely from the various approaches and methods which are available.

This approach will demand a new kind of textbook. The book will need to carry throughout its pages a parallel development of those compartmentalized areas we now use. The basic principles and common understandings of algebra, geometry and arithmetic will appear in the same text, working together for a more efficient use of each other. These three areas when developed together will enable the student to extend himself into phases of what is now considered college mathematics. Certain items from calculus, analytical geometry, differential equations, and others will be used to assist the high school student in developing a fuller understanding and appreciation of mathematics. Texts cannot be books of specific directions under such a system; they must be books which direct thoughts and suggest procedures. The book needs to be a motivating factor, a map which enables the student to observe general relationships but leaves the solution up to him.

If we are to develop an ability to select wisely we must meet another major consideration and that is the need for thorough understanding. No longer can we rest on our laurels and treat mathematics as a tool subject. If it is only a tool the user needs but to be given a demonstration of how to use this tool on a particular production line. He then continues to use it in the same situation over and over again. But if he were to find himself on a different production line he would be unable to operate it or adjust himself to the situation. Some texts have encouraged learning as a mere tool by giving an illustration on a page and then following it by exercises to be solved by that method only. All goes well until you introduce a page of miscellaneous exercises. If a tool is simple, perhaps transfer can be made without much understanding, but if the tool is complicated, it needs to be understood in basic principle if we are to be able to meet and use it in several different situations.

Meaningful arithmetic has been the cry for several years. Now meaning is absolutely necessary but there is more required than just

meaning. We must provide for practice, the kind of practice which requires thought and selection. Drill for automatic response no longer plays a vital role because we now have developed mechanical computors, robot brains, etc., to handle those computations which were solved by man alone. We have good control over these most of the time; we understand the principle on which they operate and have a quantitative concept of their results but we cannot spend time handling routine which they handle so rapidly.

Even if we can use mechanical devices to handle many of the details we still would not be likely to succeed without true concepts. Concepts are of great importance in a field which has developed beyond the tool stage. As time goes on, less time will need to be devoted to the computations—in the bank, grocery, and oil stations man won't worry about the calculation but he must have the general concept of quantity and process. To give you an illustration on how I fail to teach for concepts, one of my former students got married immediately after graduation. After the honeymoon he took a position with the A and P for $220 per month. This was his first position and probably his first real money, so he proceeded to spend it:

$60 rent
$10 payment on refrigerator
$50 payment on car
$10 income tax
$50 payment on furniture
$ 5 Blue Cross
$15 insurance
$18.75 monthly bond by payroll deduction.
What did he do with the $1.25 left from his monthly check?

His concept of quantity was not very good. In fact, his concept and that of the national government is probably about equal. The national budget for this year is about 60 billion dollars. Now, how much is a billion? Ask your state senator and see what he replies. We need to spend more time thinking about these quantities, for only in this way can we hope to recognize them in all situations. A whole new attitude can be developed when the emphasis of mathematics is placed on the concept rather than on the product of the tool. Answer books become less important. More consideration is given to phases of the work where complete solutions to the problems are not required. The illustrative material will be more closely related to the pupil's experience since only through experience can a concept be clearly obtained and made a part of a particular individual. One of the criticisms of the past has been that mathematics has built for itself an ivory tower and in no way recognizes its relationships to other areas in the recipient's experience.

As was previously mentioned, the subject content of mathematics

is constantly changing but none can say that we need to discard any portion of it because it is inherently worthless. We discard merely because we find something more nearly meets our purposes. We perhaps have placed too much emphasis on content. The other day I gave a methods class of mine a question which went something like this: "How do you account for the falling off of interest in mathematics as the student progresses from grades 1–10?" Without exception, their responses involved the teacher. Not once were they unhappy with the content. Perhaps this may be because their knowledge did not enable them to place blame where it should be. But in any event the teacher reaped the results. Let us take a look at the teacher of the next half century. This is important because what the student gets is probably directly proportional to the teacher's ability. Without question, he will be a four-year graduate. This becomes necessary because many universities are now taking directly into advanced courses in college, people who have had two years of high school algebra, trigonometry, or analytic geometry. This is as it should be, now the burden of proof is placed exactly where it belongs. The teacher will no longer be able to hide behind the smoke screen of the student's repetition in college. If the student fails in college because of a poor background, the teacher knows who to blame. The level of instruction in the junior and senior high school mathematics courses will need to be held at a high level, but the curriculum will not be stymied by mere repetition of what they cover in a similar college course. The teacher will need to be informed beyond those courses which he teaches. In seven states there are no state requirements in mathematics which mathematics teachers must meet. All but 12 of the 48 states require 15 hours or less of training in mathematics. This fact will disappear, and is disappearing in many states, through school city action rather than through statewide action. One high school principal in Indiana asks every new applicant for a position in his school to write on the board a differential equation and then discuss it in relation to his teaching of high school mathematics. This is another indication of the future need for selection and choice of methods which are not only the most economical to use but which also give the clearest concept of the operation at hand.

The teacher, as has always been the case, holds the key to the future. If he is to do the job as it should be done, his training must fit his characteristics and needs. This means a more individualized method of instruction with common general principles but differentiated details. Such a program must be a broad education in related areas of science, astronomy and economics. We now have several states which will not issue a teaching certificate in physics or chemistry without mathematics, nor in mathematics without a science.

The science of numbers and the basic principles back of the structure of our number systems must be a part of the training of all our mathematics teachers. As these mathematics teachers pursue their work they will begin to see it more and more in its true light. They will recognize it as a science with a beautiful structure as well as a tool of inestimable value. These teachers will not cease to grow after graduation as so often happens, but they will continue to contribute and receive from such organizations as this, from workshops, and many other in-service training media which will increase in the next 50 years. Throughout the training period an attitude of critical analysis will be maintained and it will become a part of this teacher, who will then lead his students into the same patterns of thought. This teacher is no longer an isolationist but will be a utilizer of his community resources. The day will come when some work experiences will become a required part of every teacher's activities in preparation for teaching. As the teacher develops, guides and directs, so progresses the youth of the nation. What kind of a working philosophy do you suppose a teacher would have who has been molded by such experiences? Perhaps his philosophy would be at least a hybrid of that of John Dewey. Learning takes place through activity if such activity is properly directed.

Such a teacher would think of mathematics as a laboratory science. A laboratory need not be filled with many gadgets and evil smelling vials, but it is a place where problems are worked out and experiments are performed, where discussions of the authenticity of results are held and where conclusions are drawn from thorough analysis of the data. In the past three years I have been in several mathematics classrooms which seemed to me to be laboratories. Answers were not known, checks were made throughout the process rather than just on the final conclusion; changes in conditions were set up and the variation of results observed. Such is the laboratory of mathematics, and more and more we will find such a program contributing to our progress. Through offering such opportunities to our students we develop Einsteins, Veblens and all the rest. The laboratory approach will insure more meaning with which the student can carry out other similar activities in high diversified situations. The all-important factor of thoroughness is encouraged because only with the completion of an experiment and its careful checking can we put faith in our results. The inductive method becomes a part of the pupil and he begins to look beyond the dead-end road of one answer.

However, the laboratory approach can never be fully realized in a highly compartmentalized environment. Laboratory technique taxes the equipment room to the limit. Therefore, we must no longer set up rigid barriers between the various fields of mathematics. At

times you may have commented about another teacher seeming to get into your subject area. But did you ever stop to think how silly it is to restrict the student to two dimensions in grade 10 and then expect him to reconvert to three dimensions in grade 11? What value is there in using a geometric proof when an algebraic proof serves the purpose to a better degree? Should algebra be deprived of the value of rigorous demonstration? Algebra provides as many opportunities for formal demonstration as geometry if we wish to take advantage of them. Why spend a year in freshman algebra and then not allow that student to use his knowledge for another full year? We must develop a program of mathematics which uses what we have throughout the training period and we must develop it in such a way that we will have available, when needed, those concepts and skills which will provide us with the most efficient, interesting and understandable development of the problem at hand. We must develop a program so that at any time in his training period the student will have a working machine. In some cases it will be a crude, inefficient one but still enough parts will be there so it is usable. All courses must be terminal all along the line. It is true mathematics is sequential in certain aspects; it is logical and orderly but there are several different logical sequences for most any argument. Now we can choose the best sequence for our purpose.

General mathematics has had a bad name in some states but not through the fault of its purpose. It also was handicapped by no one to teach it. The principle of letting the various fields help each other was not a part of the training of most of us in this room. That is being changed. It sometimes surprises me at the number of colleges and universities that now have beginning courses which are not compartmentalized. In this connection the double track plan has met some serious problems. The difficulty has been that such a second track has been a dead-end road, leading nowhere. As we look at the curriculum of many schools we find this second track ending in the bush with no means of going forward or returning. Do not misunderstand the implication; we should not discard the individual and treat all people alike, but with the coming of the laboratory approach those teachers with better backgrounds, more experiences and better concepts can do more things for pupils and still let them stay within the group. In a thinking world where all have equality at the polls, segregation at any stage is not good. We can teach much better and in the long run with a more lasting effect by following the one track but taking in various sections of the scenery along the right of way. It is not only horizontal progress which needs encouragement but also vertical progress. In time to come, many new mathematicians can be recruited from the ranks of high school students because the single

laboratory track not only allows for but demands personal development and encourages self-initiative.

With concepts and understandings carrying more weight, evaluation will be much more than checking answers. For this reason the effect on the pupil will also be noticeable. Evaluation will be a total operation rather than evaluation of just the results. Completely new types of measuring instruments will be devised. We are just beginning to scratch the surface in this all important task. Such men as Bjarne Ullsvik have the idea and we look to them for future development. Critical judgment, general analysis, choice of approach, methods of assurance, interpretation of results and analysis of variable relationships will all be measured and no pupil can be satisfied if by some hook or crook he managed to get that all important answer. When he has finished his development and feels ready to be tested in all these areas he will have confidence in himself and a feeling of pride in his accomplishments.

With a more careful and purposeful program of evaluation will come an improved plan of guiding and directing pupils into the proper fields. We shall also find these pupils entering into their work with a clearer understanding and a better knowledge of the purposes and objectives of the work which they are to do in the future. The mathematics teacher will become a better advertising agent in getting before students and public the quality and quantity of his work. This dissemination of information will encourage more participation by labor and industry in the building of the school curriculum. We will not be tied to what are the needs now but it will develop into what are those phases of mathematics which may be used to enable us more efficiently to carry on the problems of industry and government.

The curriculum will continue to advance through the encouragement of such community desires. There has been some discussion about the weakening of high school mathematics through the years, but I believe there is little basis for such comments. It is true on some levels that we have diluted, but the top today is much higher than the top of several years ago. That top will continue to rise not only because of better teachers but because of better understanding by the pupil. The pupil who understands can proceed to much higher achievements on his own than the pupil who can only compute. With this individual development comes a greater interest in mathematics and therefore a more worthwhile structure is builded by him.

Teachers trained in mathematics and other fields of science are more inclined to appreciate the problems and understand the mathematical needs of these areas. The core curriculum is not the only answer but more related work will be carried out between the fields.

Teacher cooperation and group planning provides for a program where the student uses what he knows. We are all agreed that transfer of training is not automatic, but we can certainly provide the opportunity and a good reason for transfer during the pupil's school career. The relatedness of subjects establishes in the student a feeling for common elements and he begins to think in terms of a broader picture than the four walls of the mathematics classroom. The correlation and fitting together of two or more subject areas in the school prevents formalized curricular construction. A continuous reorganization of the curriculum, not only of its details but even perhaps the molding of some of the principles to more nearly fit the changing needs of the area, will be required. This curriculum will constantly be subjected to evaluation measures because any operation which is in a state of flux must be periodically checked or we soon find ourselves far from the goals we had hoped to reach.

We will find mathematics more and more filling two needs in our society. These needs are the practical and the cultural. Mathematics has a definite contribution to the cultural background of each and every person. The historical development of mathematics is parallel to that of the rest of society. Many historical items take on more meaning when all approaches are considered.

Some things can be explained because of the nature of numbers. For example, the first astronomers thought it took the pole star 36,000 years to complete its orbit. We might spend years trying to determine how they may have calculated and gotten such a value if we did not know that 36,000 is 1/360 of the nuptial number, an all important number in that day and age.

Mathematics no longer will be overlooked as a cultural subject on even an elementary level. Read if you will in the November, SCHOOL SCIENCE AND MATHEMATICS the article by Marybelle Garrigan entitled, "Appreciation and the Young Mathematician." Giving the intrinsic cultural values of mathematics a chance to bloom along with its practical values will have a lasting effect on its motivating power, its understanding, and its permanent contributions.

As you come up over the hill for the first gaze into the valley beyond, you get an impression but often fail to isolate what parts of the valley create in you any particular response. The contributions to mathematics instruction in the next half century will come partly from the subject itself and partly from those who use it. Instruction will be difficult but rewards will be greater because we will have a more thorough understanding, and clearer concepts. The teachers will be better prepared not only in mathematics but in related areas where we can profit by correlating with other instruction, growing through experimentation and constant evaluation. Mathematics is a

laboratory science and will be taught through experimentation and evolution. The next 50 years will see the ripening of the fruits of the efforts put forth by those hardy pioneers in the field of mathematics teaching. The nation will then be conscious of the benefits it is receiving. The next 50 years will witness, not a revolution in mathematics, but a distinct evolution. May I add one word of caution: those of you who meet in this room to pay your respects to what has happened in the last half of the 20th century, take one backward look, then quickly turn about and face toward the first half of the 21st century.

ATOMIC BINGO

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Various methods have been devised to aid the classroom teacher in the instruction of students about the modern concept of the atom as advanced in the electron theory of matter. I should like to explain and to recommend a particular method I have found to be effective as well as entertaining for the pupils.

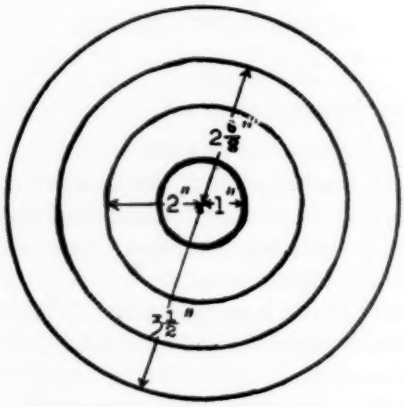
I have learned through experience that the teaching of atomic structure and related principles of chemistry can be simplified and clarified through the use of a so-called "atomic bingo" game. Design cardboard cards with concentric circles; see the accompanying diagram for suggested dimensions. The innermost circle represents the nucleus of an atom; the second circle represents the first energy level or the *K*-electron orbit; the third circle represents the second energy level or the *L*-electron orbit, and so on. Secure map pins with different colored heads to be used as the atomic particles; any color scheme may be used to symbolize electrons, protons, and neutrons. Some teachers might find it easier and more economical to devise other means of representing the atomic particles in lieu of map pins. When the teacher wishes for his class to play the game, each student is given a card and an adequate supply of map pins.

When everyone is ready, the teacher will say the name of some element, preferably one with a relatively small atomic weight; let us consider "helium." The student must recall its chemical symbol, locate it on the periodic chart of the elements, interpret the data found thereon, and proceed to construct an atom of helium. He must stick two map pins representing electrons on the second circle, and he must stick two pins representing protons and two pins representing neutrons in the nucleus. The first student to complete his graphic card and to yell "ATOM" is the winner; of course, it is always neces-

sary to do the conventional checking of the winner's card before the cards are cleared for a new game.

Let us now consider "carbon." Once again the student must think through the various operations of association, location, interpretation, and construction. He must stick two electron pins on the second circle and four on the third circle, since the first energy level is satisfied with two electrons. Then six proton pins and six neutron pins must be placed in the nucleus to make the pictorial representation of the carbon atom complete.

This "atomic bingo" method has its merits in that it can be used to teach atomic structure and use of the periodic chart of the elements.



The teaching of periodic classification, symbols, electron distribution, atomic number, atomic weight, valence, and isotopes is made easy by this "game" method.

Atoms of electrovalent compounds can be constructed to show the loss and gain of electrons and the consequential electrical attraction of the atoms because of the fundamental law of electricity. It is also possible to show with the cards how atoms of covalent compounds share their valence electrons.

After the teacher has accomplished his purpose through use of the "atomic bingo" cards, he and his students might find them useful in the construction of a bulletin board showing the electrical nature of all matter as evidenced by the structure of the atom.

Encourage free schools . . . Resolve that either the state or nation, or both combined, shall support institutions of learning sufficient to afford every child growing up in the land the opportunity of a good, common-school education, unmixed with sectarian, pagan, or atheistical tenets.—Ulysses Simpson Grant. From an address at Des Moines, Iowa, September 29, 1875, before the Society of the Army of Tennessee.

THE NATURAL SCIENCES AT THE JUNIOR HIGH SCHOOL LEVEL*

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The natural sciences at the junior high school level and my first-hand experiences with teaching one or the other of them take me back to a dim past. During a long period of college teaching since that time, particularly in certain phases of biology, my experiences force certain conclusions. I have decided therefore not just to talk *about* the subject assigned me and thereby probably evade some of the real issues that are pertinent to all of us here. I shall rather try to face a few of these issues frankly.

Only a few weeks ago, I was chatting with one of my younger colleagues who is teaching freshman college chemistry and, incidentally, she remarked that she was or just had been teaching her students to transcribe the terms and figures of the Fahrenheit thermometer to equal expressions of temperature on the centigrade mercury column. Her remarks really did *not* surprise me although I recalled having taught the same thing more years ago than I care to recount now, to seventh graders! This problem was at that time a part of the arithmetic course, just as the whole of the metric system was included in the grade work, along with a good section on mensuration, as it operates in the English system. I spoke of this conversation a little later to another of my co-laborers and she rather resignedly remarked, "Yes, five years is about the length of the period which the present-day students are retarded."

Some years ago, perhaps as many as twenty, while teaching a freshman college class in general botany something about the distribution of certain plants which are found only in the tropics and sub-tropics, I sensed a rather bewildered expression on some of the faces before me. After a little questioning, I discovered that such language had to be interpreted. Directly I was made aware that their concepts of latitude and longitude, of the hemispheres, the zones and their imaginary boundaries were, at best, very vague and non-functional. Since that time I take nothing for granted in the field of geography and keep a globe nearby in order to make some of the references in the biology texts really mean something. In the course of time I have learned too that such terms as climate, latitude, altitude, temperature, weather—each seems to connote something somehow related to each of the others, if not identical with it; but there is

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usually nothing definite or precise about the relation and limitations of these terms. In an effort to teach ecological phenomena, these factors are all important and cannot be side-stepped. It is highly desirable, therefore, that the high school graduate be able to interpret maps and globes; he must be familiar too with the use of the thermometer and the barometer, the yardstick and the meter stick, if all such instruments and equipment are to be more than laboratory decorations. If this work is not accomplished in the arithmetic and geography classes, it will have to be done as soon as the application of such knowledge is necessary. I would not, however, for a single minute have anyone here think that I would place the whole burden of teaching these fundamentals on those who labor in the natural sciences at the seventh, eighth, and ninth grade levels; but I would beg of you that whenever you find deficiencies in basic knowledge, that you give these immediate attention before trying to teach something upon which such knowledge depends. Moreover at the junior high school level, these fundamentals can well be taught more or less as ends in themselves without any embarrassment; whereas later they are merely a means without which the end cannot be attained.

A good sense of proportion, wherever this may apply, can never be over-estimated. Recently I undertook a simple mathematical method of developing an appreciation of the relative number of species in the four great groups or phyla of the plant kingdom; thallophytes, bryophytes, pteriodophytes and spermatophytes. The approximate number of species in each of these great groups of plant species is given in the textbook, and so I asked my freshman class to draw a circle and to indicate approximately by sectors of this circle the fraction of the plant kingdom that each of the four phyla should occupy. This was an assignment for outside preparation and, a little later, two among the best students in the class sought me out for some additional suggestions on this problem. And a problem it seemed to be; for only these two and a few others produced acceptable results. I again took up the problem in class and subsequently included the same requirement in a test. This time I suggested that they use a straight line which they were to divide into segments which would represent the approximate number of species in each phylum. The second set of results was much better; but the whole experiment proved to me that I am dealing with students, the majority of whom have a very weak conception of proportion.

Methods of Teaching the Natural Sciences

There is much to be said about the various methods and techniques employed in the teaching of the natural sciences, most of which apply to all of them. There is a danger, I think, of sometimes intro-

ducing and treating scientific subjects as isolated units or of hacking them into pieces. To appreciate any *effect*, the corresponding *cause* cannot be neglected; the *part* is usually relatively unintelligible without the *whole*. Such basic principles as these must not be ignored or minimized. As a biologist, I shall try to illustrate this point with an example from life. Life itself is possible only through the harmonious activity of sometimes very complex organs which form systems that control complicated processes and operations. Thus the living being maintains life, grows, and generates new individuals which perpetuate it. Therefore, when presenting any principle or process of life phenomena, although we may place the emphasis on a single organ or system or phase, we should, as far as possible, present the picture as a whole.

In case you should wish to teach fruit structure, for example, there should always be on hand some of the flower buds and transition stages between the full-blown flower, as a middle phase, and the unopened bud at one extreme, with the fully matured fruit at the other. It is not difficult then to show seeds and seedlings of the same plant, the adult of which will show the root, stem, leaves, flowers, and fruit. If your course is in the fall, the snapdragon with its large attractive inflorescences in many stages of development in well-graded transitions from the base to the apex of the flower cluster, will serve your purpose. The petunia and the spider flower are also good examples of this process and, if you have access to a kitchen garden, the tomato plant will demonstrate these steps very effectively. The pupils can readily see what happens to the pistils of these flowers as the stamens and petals wither and fall. According to the species they will notice what flower parts may adhere to or merge with the ripening ovary in fruition. In the springtime, the strawberry, the tulip and some of the wild flowers, such as the bloodroot and the dog-toothed violet may be used for this study. The ripe seeds of these or similar plants, if sprouted at this time, will supply the missing steps in the complete life history of these common plants. In the absence of these latter, good pictures or other illustrations may be employed to fill in the gaps in the complete life cycle. Life histories of some of the animals, the insects, for example, are relatively easy to demonstrate. The all too-common house fly is an excellent subject for this study.

I believe the same principle applies to problems in physics and chemistry and to the earth sciences as well. Evaporation, for example, cannot be fully understood if liquefaction and solidification are not also made clear. One cannot fully appreciate the release of energy if the storage of it is partially or completely neglected. Oxidation processes should be contrasted with reduction reactions; decomposi-

tion or analytic processes with synthetic processes, and so on.

As the years pass, one is increasingly convinced that much of the laboratory activity in our schools and colleges too is only a waste of time because it is not productive of the right kind of results. Many laboratory exercises which are dignified with the name of "experiments" are so carefully dictated, step by step, in a laboratory manual or work book, that they give the worker no challenge because he already knows what his results should be. These exercises apparently at least have for their objective the turning out of a notebook, or worse still, a workbook in which all is done but to fill out a few blanks. Too often such results are borrowed or copied data which are made to pass for original work.

In the European schools the demonstration method has always been employed, especially at the lower levels; and it occupies a very important part of the lecture in the universities. The European professors have well-trained technicians (some of them doctors of philosophy) who assist them with the demonstrations and are responsible for the set-up and care of the apparatus. Many of the so-called experiments in our American schools would be better performed before the class by the teacher with the assistance perhaps of some of the more capable students or by such students themselves under the direction of the teacher. The teacher with the other students should ask thought-provoking questions as the laboratory exercise proceeds. In this way, better results will be obtained and with a much greater economy of time and space and with the minimum of equipment. Such laboratory exercises as furnish data for mathematical calculations may be completed in the same class period—each pupil shifting for himself.

Demonstrations which are concerned with biology, especially those features of it which treat of form and structure and some of the biological principles, such as symmetry, metamorphosis, metamerism, protective coloration, regeneration, etc., as well as some of the ecological aspects of living things, can be demonstrated in the laboratory and the field with small difficulty. A few home-made charts and posters, preferably prepared by the pupils themselves under teacher direction, will not only be good teaching exercises in themselves, but they will add to the laboratory stock of equipment for future use. The best of such preparations can be used year after year and will always serve as stimuli and challenges to the incoming classes to do similar work.

Many of the common natural phenomena of everyday life are splendid illustrations of physical and chemical reactions. Too often these are not recognized as being sufficiently dignified to rank as academic problems. For the demonstration of common natural phenomena, very little commercial apparatus is necessary. For exam-

ple, the expansion of water as it approaches the freezing point, evaporation, condensation, crystallization, determination of wet and dry weights of various objects and substances, the melting and boiling points of common fats, all are feasible and practical problems. Indeed, a textbook of natural science should be suggestive, consultatory and, sometimes, confirmatory, rather than slavishly followed. All pupils who show any special aptitude for investigation should be encouraged to take up an individual problem, however simple this may be. It is enough if the project is original with the pupil. Let him then devise his own equipment and work out his own methods as far as possible. All acceptable results from such investigations should receive their proper recognition and rewards.

The home, especially the kitchen, is a splendid laboratory in every sense of the word for the girl or boy to observe and apply the basic principles of natural science in operation. Here the scientific terminology and the mathematical exactness of the class room come alive and should lend dignity and promote greater respect for the most ordinary duties in the home, such as the chemistry and physics of dish-washing and laundry work. All of the girls should be interested in the countless applications of the natural sciences in the preparation of foods and clothing and to problems of home management. All are living in homes or other buildings which must be heated, lighted, ventilated, and kept sanitary. What a place is the modern home, with its telephone, frigidaire, radio, television, vacuum cleaner and numerous other electrical appliances and equipment! Here one can enrich the knowledge, the fundamentals of which are acquired in the more formal way in the school laboratory and class rooms.

Visual and Audio-Visual Aids to Education

We hear a lot now-a-days about visual or audio-visual education. Of course, this is only a new name for a very ancient human custom. Teaching was probably never of a kind that ignored the gift of bodily sight or hearing. The use of the written word, of figures, graphs, maps, and charts, or illustrations of some kind or other, is probably as old as education itself. The observation of natural objects, both living and inert, has probably always been employed in the acquisition of knowledge about the material things in nature. In mathematics, geometrical designs and objects, signs and formulae mark the development of the science of numbers, the study of quantity and form. And was there ever a time in human history when sound—whether naturally or mechanically produced—had no educational value. Can anyone imagine a human mother without a bedtime song or story!

These new-sounding names, "visual education" and "audio-visual education," for an age-old custom, came into use with the advent of the film strip and apply especially to sound and motion pictures, to the radio and television, so that the machine-operated types of visual and audio-visual aids, seem to be identified with the whole idea of the functions of the eye and the ear in education.

A phonographic record or any good recording, whether for the study of a musical composition or good diction or in learning a foreign language makes a very good aid to ear-training. This kind of audition can be repeated according as the need requires it, and is not like some swift-moving pageant which may tease the eye and the ear for the moment but is immediately gone with the wind. The same principle applies as well to the judicious use of good lantern slides or other motionless illustrations—all of which can be leisurely studied as supplements to the regular class, laboratory and field work.

The great danger from excessive or unwise use of mechanical aids to education, as for example, going-all-out-for audio-visual-aids, is that these tend to diminish or to soothe mental reaction. Too much is done outside of the mind and too little within it. Only in the proportion that outside stimuli influence or challenge the potential mental faculties, are these mechanized aids useful and cooperative in the learning process.

Any worthy object or phenomenon outside of the mind which stimulates thought and reasoning, activates the memory, or feeds the imagination, has educational value; but there must be the right proportion between the stimulus and the response. When the moving picture or television performance is so complete in itself as to leave very little to the imagination and almost nothing to provoke thought or inquiry, it may entertain and distract but it does little to provoke an attitude of investigation. This type of mechanical aid should, therefore, be used with discretion only; that is, when the nature of the theme is already sufficiently clear through personal effort. Then the screen production will serve as a comprehensive review rather than as a preview.

A screen demonstration, like everything else which may be employed in the teaching process, serves best the one who takes the most to it and is, therefore, prepared to appreciate it. Adults who are familiar with a subject through personal study, through reading and other experiences, can easily be deceived into thinking that those who have had little or none of these previous preparations are seeing and understanding a certain rapidly moving reel even as they. For example, the process of cell division by mitosis makes a splendid film; but the one who has made no real study of this process in the regular routine way, may possibly deduce some very bizarre and

erroneous conclusions from such a demonstration, if he reacts to it at all. He, of course, who has learned the most about the whole process is the man who prepared the film strip. He has followed the process with great care and much study and his reproduction of it will be intelligible to others only in proportion to the amount of real knowledge they bring to this demonstration.

An artistic rendition of Bach might even greatly please a listener who has no musical training but who is naturally musical. It cannot however do for him what it affords the serious student of music—even though the latter is naturally less endowed. Always the learner's efforts and his serious cooperation are of paramount importance in mental development. Education is that drawing or leading out process in which the learner is the chief and most important participant. True learning cannot be bought or borrowed; it is a personal achievement which is acquired largely at the expense of one's own labor and perseverance. Learning is not a painless process and was evidently never intended to be—not since that first rebellion in the Garden of Eden. This, all of us should have learned long ago, just as we learned that ever since that first fall, man has been obliged to earn his bread in the sweat of his brow.

Visual and audio-visual aids to teaching are all good in themselves, each in its own degree; but as methods of education they should not be made to compete with or to substitute for individual study, observation, and investigation. At their best they only supplement or recapitulate the results of personal effort. In other words, there is really no get-rich-quick method of education.

The Senses, Memory, Imagination and the Higher Faculties

Training for the correct use of the bodily senses and the dexterity of the hand is necessary for the mastery of the natural sciences, as are also the memory and the imagination; but in the learning process, these lower faculties—all of which we share with irrational creatures—are only the servants of the strictly human faculties, the intellect and the free will. On the other hand, the neglect of the memory and the sense faculties in the young child and their proper use in the acquisition of mathematical axioms and formulae, geographical facts and data, etc., seriously handicaps him later on; that is, when he has reached the age when such knowledge should serve him as the tools and material for the formation of judgments. There is something here, however, that we should not forget, particularly at this level, and it is that relatively very few of these pupils are going to become professional scientists. Nevertheless all must learn to think. We should exercise care then that we do not over-stress laboratory per-

formance and various techniques which are most necessary for the budding scientist but of relatively little importance to the majority. This should never be done at the expense of the exercise and use of the more strictly rational powers—faculties which all must learn to use, be they scientists or not.

In my own experience, I find that the average college freshman would rather be *told* an answer than to try to work out one which would be her very own from facts and principles. She is thus ever ready with pen well-poised to take a dictated statement. It is so much easier temporarily to memorize a few bits of subject matter which may tow her through some inescapable contingency, such as a semester examination, than coolly to sit down before the facts and principles to reason out a firsthand definition or conclusion. I use the feminine pronoun here because of my limited firsthand experience in teaching boys or young men. Secondhand information, however, leads to the conclusion that the same condition prevails also in co-educational institutions. Often too my own students are the products of co-educational secondary schools.

Thus the order is reversed. Such intellectually retarded youth were evidently not required to exercise and store the memory when they were children; and later, when they should be able to reason from principles and facts, they are quite content to make use of a latent memory. Thus they have not yet really learned fully to think. Naturally, thinking is the most difficult activity of which the human being is capable—whether he thinks about God and the marvels of creation or his personal rights and duties or his eternal destiny or about the scientific pursuits in which his daily duties engage him. To concentrate the mental powers on some problem or process, to weigh and measure the evidence and to marshal the facts, to fit these into an intellectual picture and then to survey it from all angles in order finally to draw correct conclusions, is a complicated operation at once profound and very difficult and exacting of the human powers. The average person, young or old, shrinks from it. The growing youth, even the college student, schemes and invents various strategies to avoid it. Nevertheless to ignore or to neglect any of the potentialities and the privileges which distinguish man from irrational creatures is an attempt to live at a lower level than that which Almighty God ordained for him.

Tests and Examinations

There is a misconception which seems to be general among college freshmen at least; and it is that tests and examinations are a necessary means by which a teacher is able to compute a grade and that their function ends there. They do not seem to regard these exercises for

what they certainly should be—important factors in the learning process.

The psychological attitude which must develop when a student knows that at a certain future date there will be a reckoning of his application and accomplishments, brings a realization that facts are not learned for a day or a week or a month, but precisely to become the warp and the woof out of which he must weave an intellectual pattern. This picture must remain in his mind, and the figures of which it is composed must serve him throughout the course and as fundamental knowledge thereafter. He will learn too by experience that a thorough review—not a cramming—before a final examination is an excellent inventory of his past performance and his present status.

The actual writing of an examination is an excellent test in quick thinking and clear-cut organization and a splendid practice in the use of the vernacular. Life is a continual examination—one which everyone is obliged to take day in and day out, whether he will or not. The rapid survey of situations, principles and facts, the right judgment and conclusions and the will to act promptly and wisely, are some of the demands in the life of every worthy human being.

After the student has written an examination, if he is really a student, he will immediately check all doubtful answers and seek out the answers he was unable to make. In a subsequent class exercise the instructor should sum up the good points and the weak points in the results. When the examination papers are returned to the students, they will then better realize their faults and weaknesses and will be stimulated and encouraged with their successes.

Obviously the kind of examination that we have just considered, a *series* of exercises, is not one of the objective type. Personally I do not believe, except in relatively rare cases, that the average objective test should rank as good class room procedure—either for determining a grade or as a teaching device. It does not challenge the powers of organization; it encourages guessing; it makes no demand for self-expression, practice in sentence structure, or the necessity of revealing inability to spell correctly, to punctuate properly, etc. It *does* give opportunity for the choice of right answers which often cannot be defended by the one who chooses them. It is one thing to choose the right answer; it is quite another to give the reason for the choice. Just as in the case of the mechanized audio-visual aids, objective tests have a place; for example, as vocabulary or terminology tests, for spelling, mathematical axioms and principles, chemical formulae, and the like. But objective tests at their best, as teaching exercises, limit the learning process; and they sometimes give results which are quite unfair as the basis for grading. The

average class will probably appear much more uniform in abilities if judged solely by these tests than when the same pupils are required to write an examination of the essay type. The objective test is therefore unfair to the student whose opportunity for self-expression is denied, but who could have met all of the requirements which a thorough examination should include.

Courage under Difficulties

Throughout these rather scattered and necessarily sketchy suggestions we have at least hinted at the difficulties and defects in our present educational regime. Not all of these, by any means, are owing to faulty teaching. The many broken homes with the consequent juvenile delinquency, the high cost of living which forces a large percentage of mothers of children and youth to be gainfully employed outside of the home, are some of them. Over-crowded conditions in the school itself, over-stocked curricula, and the increased responsibilities of teachers, such as exaggerated requirements in the way of reports and statistics, assignments as committee members and moderators of various organizations, all add to an already full program and dissipate the energy which a teacher should spend in the class room, the laboratory, and the library. The school also makes attempts to substitute for what is lacking in the home—all of these—in a much-agitated atmosphere of a war-torn world, the immediate future of which is dismal and unpredictable, increase the burden of the underpaid teacher almost to the breaking point.

Many of the pupils and students of this era are children of parents who are war veterans, some of them not only once but twice. These children too have been the victims of the comic strip and unsupervised reading. They also suffer from the abuses of the cinema, the radio, and television. All of these factors contribute to the unfortunate distractions which are worse than detrimental to education in the good and true sense.

As teachers in such a milieu all that any of us can possibly do is our best. We must try, therefore, to meet these difficulties with courage and confidence, with patience and perseverance. Since first things come first, I am convinced that all of us, regardless of our particular science and its proper dignity in the curriculum, should take time out to teach the fundamentals wherever these are lacking; by which I mean arithmetic, reading, spelling, grammar, the elements of geography, or whatever else, the deficiency of which is a real block to educational development.

Search others for their virtues, thyself for thy vices.—Benjamin Franklin

MEETING STUDENT NEEDS BY INTEGRATION*

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According to the Illinois Secondary School Curriculum Program the purpose of the school is "to provide learning experiences so that the needs of youth and the requirements of society may be met effectively. The methods for achieving such an end, that is, the proper selection of learning experiences to best meet youth and societal needs becomes a basic task of curriculum construction."

Perhaps it is first advisable to consider adolescent needs before studying techniques and methods for meeting those needs. From studies made in the State of Illinois the following appear to be paramount needs of youth.

1. Developing an effective personality
2. Living healthfully and safely
3. Making effective use of educational opportunities
4. Spending leisure time wholesomely and enjoyably
5. Earning a living
6. Managing personal finances wisely
7. Becoming an effective consumer
8. Preparing for marriage, home-making and parenthood
9. Taking an effective part in school and civic affairs
10. Developing a sense of values in life

The above statements are very broad and would require considerable re-division into sub-needs. Furthermore, the listing would differ as to order of importance and significance within any community or school. Techniques for meeting these needs would vary as widely as the curricular and extra-curricular program within a school, and be as varied as the thinking and planning of the curriculum makers.

Exploration of school programs reveals a rich variety of methods for reaching and satisfying student needs. For the sake of brevity these may be listed as

1. Individual and group counseling
2. Subject matter developments
3. Classroom experiences
4. Extra-class and extra-curricular activities
5. School-community projects

In thinking of integration, we often limit our thinking to a core curriculum or a common learnings program. True, these are a form of integrated subject matter and a very valuable and useful method particularly at the freshman and sophomore levels. But integration

* Read before the Senior High School Group at the C.A.S.M.T. at its "Golden Anniversary" Convention in Chicago, November 25, 1950.

may be a working together of only two or three subject matter areas, or a combination of class and extra-class activities, or even the motivation of common thinking in several departments by committee and group work. Too frequently our teaching is too compartmentalized. We scarcely know what our nextdoor neighbor is doing unless he happens to be teaching the same subject as ourselves. And then sometimes we only hear about it through the young people themselves.

Perhaps some type of integration will create a better understanding of both teachers and students and the subjects in the curriculum. Perhaps integration can overcome too much compartmentalization and consequently prejudices and ignorance. Only by a working together can we know what is being accomplished to meet student needs, where the omissions and overlappings occur, and what the students themselves actually think about our curriculums.

Several illustrations of integration within the personal experience of the author may be useful to demonstrate the co-operation that is possible among departments and individuals.

A combined Biology-English class was the first instance of integration engaged in by the author. An English teacher co-operated in this venture which took place in Indianapolis in 1943–44. Three periods a day were allotted for this class, and these came at the end of the school day. Such an arrangement proved ideal for trips into the community and for outdoor activities. The basic material of the course was biological. The units may be briefly listed as follows: Science versus Superstition, The Out-of-doors in Autumn, Food Getting, Food Uses, Reproduction, Heredity and Change, Health and Disease, Community Development, Gardening, Economic Plants and Animals, Conservation of Community Resources, Hobbies and Vocations. From these units English derived its inspirations for paragraphs and compositions, its suggestions for letters, interviews, round-table and panel discussions, and its class reports. Radio skits and playlets were developed around the study of foods, diets and health. Articles, pamphlets and books of scientific developments, science history, and biographies of scientists furnished material for class and outside reading. Films, outside speakers, and trips were always an excellent source of ideas and topics for oral and written reports. Science words supplemented the regular English spelling lists. At the close of each unit of study a paper was written by each student, in some instances to summarize the material studied, at other times, to make application of information learned to familiar situations or to the individual himself. These papers were graded by the biology teacher for accurate scientific information, and by the English teacher for correct spelling, and sentence and paragraph construction.

One of the most interesting units of the entire course proved to

be "Community Development." While the science class studied plant and animal distribution, development of plant and animal communities and interrelationships of plants and animals within communities, the English class undertook a study of human communities. They first read novels and sketches of American life, both pioneer and modern. Selections were made by each student and the book setting and story reported in class. Indiana novels followed including several with settings in Indianapolis. The science teacher correlated the study of plant-animal and human communities for the students and in so doing gave the geographical, natural and agricultural setting of Indiana. Maps and charts were used profusely. Trips to museums gave portrayal to many aspects of American and Hoosier life.

This combined science-English course not only brought about better understanding between school departments but made possible a thorough review and use of community resources. Student evaluation proved the course worth-while not only from the standpoint of information gained, but also, from the standpoint of stimulation of new interests and appreciations.

Another instance of co-operation among departments is that which is taking place in health instruction at Oak Park and River Forest High School. A health science course, required of all freshmen, is offered by the biological science department. This course is organized into four units, tentatively titled *The Human Body, a Machine, The Young Person at Home, The Young Person at School and in the Community*, and the *Young Person at Leisure*. Films, coordinated with course content, are shown each week to students. Questions on the films are available to all teachers. These may be used for discussion, write-ups or testing. While the health science classes are not segregated according to mental ability, opportunity is given for the expression of individual differences by offering a variety of class experiments and extra-class projects. Some of the latter may involve group action, committee research, or individual exploration with preparation of reports for the class as a whole. In several instances, such as a study of the Oak Park Health Department, a composite report was set up for all the health science classes. A freshman health science club is organized each semester. The club adviser brings in community persons, such as the health commissioner, to talk to the students about important problems in health in Oak Park or Chicago. Groups of students visit agencies of health in Oak Park and Chicago and prepare reports for distribution to all freshman science classes. One of the high-lights of each semester is a trip through Chicago's housing areas—both good and blighted. This is arranged by the Chicago Housing Authority, and is usually preceded by films or speakers on Chicago health problems. This club participation in community

activities is another example of co-operation, or integration, between school and community.

Health education is not forgotten at Oak Park at the end of the freshman year but continues as an important part of the curriculum through four years of physical education, and after-school recreational activities, through biology which is an elective science after the freshman year, and through phases of home economics, social science and English. Into biology has been placed the study of heredity, reproduction, growth from birth to maturity, boy-girl relationships, behavior mechanisms, disease control, and other human interest material. Since a large proportion, eighty percent or more, of the sophomore class, and a smaller proportion of juniors and seniors select biology, perhaps little is lost by transferring these phases of health education to the more mature and stabilized student levels.

Health study in the biological sciences is coordinated with physical education, home economics and social science through a school health council. The council first began functioning in the spring of 1948 with the following personnel: The chairmen of boys' physical education department, girls' physical education department, home economics and biological sciences, a representative of the social science department, the dean of freshman girls, the school nurse, and the superintendent. Since 1948 the health council has been enlarged to include the dean of senior boys who is also in charge of college and vocational placement, the cafeteria manager, the business manager and, on occasions, instructors of sight saving and speech difficulties, and members of the maintenance staff. As occasion demands parents and community health personnel will be invited to participate in the activities and decisions of the school health council. The council meets as a whole or in part every two or three weeks.

The health council may be said to have evolved at Oak Park as the result of certain felt needs among instructors responsible for health instruction and health services. The objectives of this council may be stated as:

1. Study of student needs in health instruction.
2. Consideration of departmental offerings in health education from the point of view of sufficient coverage, overlapping, and omissions.
3. Correlation of departmental teaching with student needs.
4. Expansion of student health services.
5. Co-operation on inter-departmental health activities, such as a project on student diets.
6. Evaluation of present procedures and follow-up studies.

As part of the health program at Oak Park and River Forest High School a new course is planned for the second semester of 1950–51.

This course is to be known as *Personal and Family Living*, and is an outgrowth of recommendations made in follow-up studies. It is to be offered as an elective to juniors and seniors. While the course will draw its materials from many phases of living, its basic foundation will be understanding the facts of the biological sciences and an application of these to everyday living. Credit will be offered toward either a science or social science major. Four units have been tentatively selected: *Understanding Ourselves, Understanding our Family, Understanding Others,* and *Understanding Future Responsibilities.*

The first would develop physical, mental, emotional and social growth with the underlying theme of heredity and environment as effecting similarities and differences in growth and personality patterns. *Understanding the Family* would cover the family as a unit, the child's place in the family, and the responsibility of the family to the community. Social science and psychology as well as the biological sciences would lend assistance in developing such a unit. The third unit, *Understanding Others*, may consider boy-girl relationships, pupil-teacher and pupil-pupil relationships as well as pupil-group relationships. The latter is an important phase of this topic often wholly neglected. The last unit, *Understanding Future Responsibilities*, would quite naturally include preparation for college and vocational participation with the emotional, social, and economic aspects considered; and planning for marriage and parenthood. Under the latter phase selection of a mate, courtship and engagement, marriage, establishing a home and parenthood would be the natural trend of events. Child development and care may easily become a part of this unit, but the demands of time may prevent a detailed discussion.

Such a course as the one outlined offers splendid possibilities for the co-operation of several departments, and for numerous personal and community projects.

A last, but not least, example of integration at Oak Park and River Forest High School is that of student-teacher co-operation in the defining of needs and problems, student aid in the planning of class materials and extra-class projects, and student evaluation of existing courses, textbooks and pamphlets in the biological sciences.

In its final analysis integration is an understanding and co-operative undertaking among the various departments of a school to plan courses and procedures to meet and satisfy the needs of students. We fully realize that our students will handle the affairs of the world in a few years. If they are to do so adequately, they must learn the necessity of emotional and mental maturity. We as teachers have a rare opportunity and privilege in aiding these young people to become mature adults with integrated personalities. The question remains—can we do this big job by teaching within our own little com-

partments, or do we need to break down the barriers and join our fellow teachers in a better integrated and co-operative program for meeting the needs of our youth? This may mean a revised and reorganized school curriculum. It may mean deletion of courses which no longer teach a way of living, in order to set up courses which more fully satisfy student needs. Perhaps subject matter areas are no longer the answer, but rather life situations and everyday problem areas. The answer will naturally vary in different communities and in different administrative setups.

Statistics will continue to point up the number of dropouts in schools and follow-up studies will give an analysis of student opinion on the courses we offer. These facts may be quite revealing, and cause concern as we question the reasons. Perhaps they tell us the time has truly come for curriculum reorganization and for better integration in order to achieve the primary function of secondary education. Are we ready to accept the challenge?

GROUND CONTROL OF PLANES IN FLIGHT BY RADIO PRIME FACTOR IN SAFE FLYING

Almost constant radio contact between pilots in flight and government ground control stations is a prime factor in safe airplane transportation, it is indicated here today by figures released by the U. S. Civil Aeronautics Administration.

During the first eight months of the past year, over 4,000,000 radiotelephone contacts were made by CAA ground stations with pilots in the air. This is over three times the number of such contacts for the first eight months of 1949.

Another major service given by CAA communicators to pilots flying the 60,000 miles of airways is pre-flight briefing. This includes weather information, airport conditions, radio aids, terrain and minimum safe altitudes along the route. Some 1,225,000 such briefings were given pilots during the first eight months of this year, nearly twice as many as during the same period of one year ago.

MORE PEST-CONTROL AIRCRAFT WILL BE NEEDED WITH CROP-CONTROLS REMOVED

More planes will be needed next year to help farmers produce bigger crops, it was indicated here today by officials of the U. S. Civil Aeronautics Administration. Their great use is in pest control.

Aviators play an important part in modern farming by spreading pest-killing dusts and sprays from the air on many of the major crops and on forest trees. They also distribute seed and fertilizer to rice fields and burned-over areas following forest fires. Some 5,000 airplanes and helicopters are now used for these purposes.

More aircraft to aid farming will be needed next year because of increased acreages which will follow the action of the government in removing production controls on all crops except peanuts and tobacco. With the growing use of chemicals to kill weeds, more use of planes in weed-killing is expected. In addition to weed-killing chemicals, others are now coming into use to destroy woody plants such as scrub trees on pasture land.

CHEMISTRY AS APPLIED TO SOIL MANAGEMENT AND CROP PRODUCTION*

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Research work as applied to the problems of soil management and crop production generally follows through four steps, as follows: 1—research in the basic fundamental exact sciences including chemistry, physics, geology, and botany; 2—research in the applied sciences including agronomy and horticulture. (Experimental field test-plot techniques and statistical methods of analysis are essential tools for effective research work in the applied sciences); 3—field-plot research and demonstrational fields; 4—the culmination is reached when the new findings are applied by farmers in a competitive agriculture.

The study of soil has become so specialized that today there are separate branches of specialization, namely; soil physics, soil chemistry, soil microbiology, and pedology. Also, special attention is now being given to the study of soil colloids. The equipment and supplies used in a soil research laboratory are similar to those used in quantitative, colloidal, and physical chemistry.

THE SOIL IS A CHANGING SYSTEM

Soil may be described as a dynamic natural body on the surface of the earth in which plants grow. It is differentiated into horizons, which differ from the parent material below in morphological, physical, chemical, and biological properties.

The soil is a dynamic physio-physico-chemical system from which plant roots absorb water and nutrients which, in the presence of light and chlorophyll of green leaves, are combined with carbon dioxide of the air to produce sugars, starches, proteins, cellulose, hemi-cellulose, and lignins. These elaborated organic materials are the source of all our energy, and ultimately return to the soil to be decomposed by the micro-organisms that live therein. In the process of decomposition the organically bound nutrients are released for use again by the plants. In addition, many organic acids are produced which assist in the weathering and release of additional plant nutrients from the primary soil minerals.

There are present in the soil certain bacteria that have the capacity to fix atmospheric nitrogen, which under optimum conditions in the laboratory, have increased the soil nitrogen content at the rate of approximately thirty (30) pounds per acre per week. There are still

* Read before the Chemistry Section at the C.A.S.M.T. at its "Golden Anniversary" Convention in Chicago, November 24, 1950.

other bacteria in the soil, commonly known as denitrifying bacteria, that have the power to reduce nitrates to molecular nitrogen. The many macro- and micro-organisms that inhabit the soil are vital to the nutrient cycle and in maintenance of soil structure. The soil is truly a changing system in which oxidations, reductions, and other physico-chemical reactions are proceeding continually and simultaneously.

Soil Colloids Are Important

For convenience of study and classification, soil particles are arranged into groups called separates or fractions. These fractions are separated on the basis of particle size. The size classification adopted by the International Society of Soil Scientists is given in Table 1.

Table 1. Soil Separate Classification

Soil Separate	Diameter Limits Millimeters
Coarse sand	2.0–0.2
Fine sand	0.2–0.02
Silt	0.02–0.002
Clay	less than 0.002

The real significance of the different particle sizes results from the increase in internal surface area as the particle size decreases. This relationship is shown in Table 2. It will be noted that when a particle is reduced to one tenth the previous size, the number of particles is increased one thousand times and the internal surface area ten times.

Table 2. Numbers and Internal Surface Area of Particles in an Acre (2,000,000 pounds) of Soil

Particle Size Millimeters	Number of Particles	Internal Surface Area Square Acres
1	65376×10^{7}	507
0.1	65376×10^{10}	507×10
0.01	65376×10^{13}	507×10^{1}
0.001	65376×10^{16}	507×10^{2}
0.0001	65376×10^{19}	507×10^{3}
0.00001	65376×10^{22}	507×10^{4}

The clay fraction of soil is composed almost entirely of weathered primary rock minerals. Most of the clay particles fall within the colloidal range (1–500 millicrons), and exhibit characteristic colloidal properties, such as:

1. High internal surface area per unit volume in comparison with particles of larger size.

2. High water retention within the structure of the particle, in contrast to sand which retains water only on the surface.
3. High expansion and contraction coefficients, as manifested by cracking of clay soil upon drying.
4. Highly sensitive to electrolytes. Colloidal clay micelles carry a negative charge when in water.
5. Low osmotic pressure.

The colloidal clay micelles exist largely as films around the larger soil particles. In the presence of calcium ions the individual colloidal micelles are flocculated, resulting in the formation of larger aggregates or crumbs. In practice, the formation of these aggregates is important, as they favor high moisture holding capacity and good aeration of the soil, both of which are extremely important if high crop yields are to be obtained. On the other hand, colloidal micelles, in the presence of monovalent cations such as sodium, are dispersed into the individual particles, and the soil is said to have a single grain structure. Under such a condition the soil is in poor physical condition for plant growth. If hydrogen ions predominate on the soil colloid, it is said to be acid, and the soil aggregates are less stable than those developed in a calcium soil. Thus, a factual basis is provided for the use of liming materials on acid soils. Aside from its nutritional value, lime improves the physical structure of such soils, and in so doing favors better plant growth.

Soil Colloids—The Seat of Base Exchange

As mentioned earlier, colloidal clay micelles are negatively charged, and the cations that are associated with them are analogous to the outer layer of an electrical double layer. The cations on the surface may be exchanged for other ions in the system by the process commonly know as base exchange. This interchange of cations takes place rapidly and is reversible. The cations found associated with the clay micelles in nature are calcium, magnesium, potassium, sodium, and hydrogen. Calcium ions predominate in neutral to slightly alkaline soils, while hydrogen is the primary replaceable ion in acid soils, and sodium in alkali soil.

The principle of base exchange was applied in the reclamation of the low lands of Holland, that were flooded with sea water during World War II. When flooded with sea water the exchange complex became saturated with sodium ions, which destroyed the physical structure and thereby rendering the soil non-productive. By leaching the sodium-soils with gypsum (a neutral calcium salt), the sodium was replaced with calcium ions, favorable soil structure developed, and the productive capacity was restored.

With the development of our knowledge of cation exchange, has come a revision in our old concept that the soil is an inert medium containing a solution from which plant roots absorb all their mineral nutrients. Plant roots absorb not only ions from the soil solution, but also liberate cations from the clay micelles which in turn are absorbed by the plant. This process is commonly spoken of as contact base exchange. It has been fairly well demonstrated that the cations which enter the plant roots come largely from the outer layer of the clay micelles, figure 1. A plant root growing in contact with the colloidal

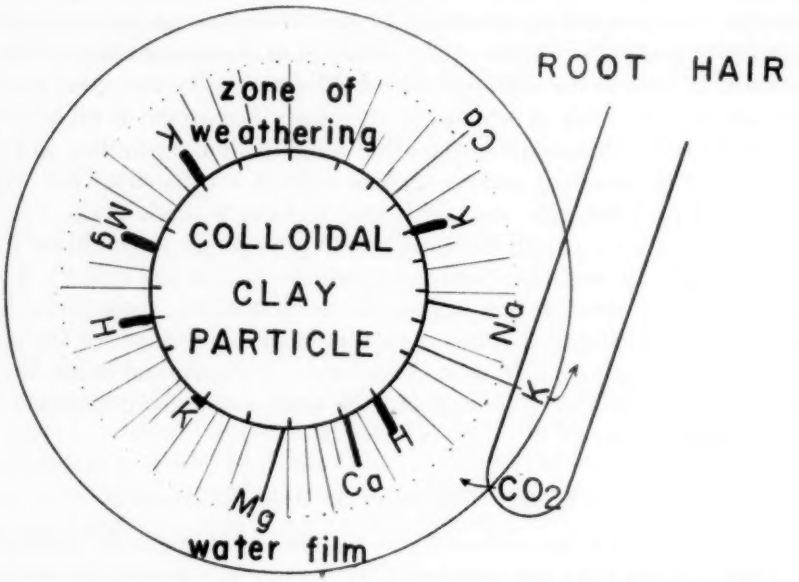

FIG. 1. An over-simplified sketch of a plant root in contact with a colloidal clay particle (micelle). The strength of the bond holding the respective ions on the micelle is represented by the lines of varying widths—the wider the line, the stronger the bond.

clay particles releases carbon dioxide (a product of respiration) to the soil solution. In the presence of water carbonic acid (H_2CO_3) is formed, which in turn ionizes to form H^+ and HCO_3^- ions. The hydrogen ion is thus free to replace calcium, magnesium, potassium, etc. on the micelle.

It has been demonstrated that for optimum growth of crops such as alfalfa and clover, approximately 65 per cent of the total exchange capacity should be supplied by calcium, 10 per cent by magnesium 5 per cent by potassium, and 20 per cent by hydrogen. If the composition of the exchange complex changes appreciably, the crop will grow poorly, until such time as the nutrients are brought back into balance by the addition of lime or potassium fertilizer or both. The

composition and quantity of materials required to bring about the proper balance are determined by quantitative chemical tests of the soil in question.

The Essential Fifteen

There are fifteen elements known today to be essential for plant growth, they are: carbon, hydrogen, oxygen, phosphorus, potassium, nitrogen, sulfur, calcium, iron, magnesium, boron, manganese, copper, zinc, and molybdenum. Until about 1920 it was considered that ten, and only ten, elements were essential for plant growth. The original ten elements can be easily remembered by a mnemonic suggested by the late Professor Cyril Hopkins of the University of Illinois, who told his students to think of "C H O P K N S Ca Fe Mg," and to read it as "C. Hopk'ns' Cafe mighty good." Since, then, boron and manganese have been added to the list of essential elements. Accordingly, someone suggested the mnemonic be lengthened to read, "C. Hopk'ns' Cafe mighty good, but mnemonic." Now copper, zinc and molybdenum have been added to the list of essential elements, but as yet no one has suggested a way to include them in Professor Hopkins' mnemonic. As more highly purified salts become available, still other elements will probably be found to be essential for normal plant growth.

Carbon and oxygen are absorbed as carbon dioxide from the atmosphere by the leaves. The other elements are obtained from the soil by the roots. On the basis of quantity required, the mineral nutrients are customarily spoken of as major, secondary, or trace elements as shown in Table 3.

Table 3

Major Nutrients	Secondary Plant Nutrients	Trace Elements
Nitrogen	Calcium	Iron
Phosphorus	Magnesium	Manganese
Potassium	Sulfur	Copper
		Zinc
		Boron
		Molybdenum

Of the essential plant nutrients obtained from the soil, nitrogen, phosphorus, and potassium were for many years considered the only ones likely to become deficient in the soil. In recent years, however, soils in certain areas have become deficient in one or more of the other elements listed in Table 3. An enormous commercial fertilizer industry has developed, as a result of the need for supplemental supplies of the essential mineral elements in the soil.

Mixed Fertilizer Terminology

The principal plant nutrients in a complete fertilizer mixture are nitrogen (N), phosphoric acid (P_2O_5), and potash (K_2O). A common fertilizer formula like 4-12-8, contains 4 per cent total nitrogen, 12 per cent available P_2O_5, and 8 per cent water-soluble K_2O, and is said to carry 24 plant nutrient units. The balance of the mixture (76 per cent) may consist of inert material or conditioners to prevent the mixture from caking and to maintain good drilling qualities. Such a fertilizer would have an N—P_2O_5—K_2O ratio of 1-3-2. If a 4-12-8 fertilizer is suitable for a particular crop on a certain soil, then any other fertilizer mixture with the same 1-3-2 ratio should be equally as good, provided adjustment is made for difference in analysis. For example, 500 pounds of 8-24-16 would be equivalent in N—P_2O_5—K_2O, to 1000 pounds of 4-12-8.

A fertilizer that carries only two of the three fertilizer elements is sometimes referred to as an incomplete fertilizer, and if only one of the elements is contained it is known as a single fertilizer. For example, an 0-9-18 would be an incomplete fertilizer, and an 0-20-0 would be a single fertilizer.

Soil Acidity Must Be Corrected First

The beneficial effects of lime on soil was discovered accidentally in France centuries ago. However, the function of lime and its influence on the availability of the various plant nutrient elements has become more fully understood only as a result of developments in modern chemistry.

The ills of acid soils are due either to a deficiency in available forms of one or more of the essential nutrient elements required by plants, or to the presence of toxic concentrations of certain non-essential elements, particularly aluminum. Consequently, the influence of lime on plant growth may be either direct or indirect. It is a well known fact that plants differ in their susceptibility to soil acidity. Certain plants are rather tolerant to high soil acidity, while others are extremely sensitive. Such a situation is explained only on the basis of the inherent differences in the physiology of plants. It has been possible over the years to classify many of these crop plants on the basis of their susceptibility to acid soil conditions. Such a classification is presented in Table 4.

Soil acidity is determined in modern soil laboratories by means of a potentiometer, using glass electrodes, and is expressed in terms of pH units (the common logarithm of the reciprocal of the hydrogen ion concentration expressed in terms of normality). The pH range commonly found in agronomic soils is from about pH 4.5 to 8.5. Any pH

below 5.0 is considered to be strongly acid, between 5.0 and 6.0 as medium, 6.5 is considered optimum for most crops, and any pH above 7.0 indicates alkalinity.

pH exhibits a differential influence upon the availability of the different plant nutrient elements. The optimum range for nitrogen availability is from pH 6.0 to 8.0, for phosphorus 6.2 to 7.5, and for potassium anything above 6.0. Calcium and magnesium are at an optimum above 7.0, and boron, copper, and zinc below 7.0. Iron and

TABLE 4. CROP ADAPTABILITY TO SOIL ACIDITY

Strong Acidity pH below 5.5	Medium Acidity pH 5.5–6.5		Slightly Acid to Slightly Alkaline pH 6.5 and above
Blueberry	Barley	Millet	Asparagus
Cranberry	Beans	Mustard	Beets
Peanuts	Bluegrass	Oats	Celery
Watermelon	Buckwheat	Parsley	Leeks
Azalea	Cauliflower	Parsnips	Lettuce
Raspberry	Cabbage	Pumpkins	Muskmelon
Holly	Carrots	Radishes	Alfalfa
Potato	Collards	Salsify	Sweet Clover
Sweet Potato	Corn	Squash	Red Clover
Laurel	Cowpeas	Strawberry	Onions
	Cucumbers	Tomato	Spinach
	Egg Plant	Turnip	Peas
	Kale	Vetch	Chard
	Lespedeza	Wheat	

manganese are more readily available at pH levels below 6.5. It is interesting to note, however, that pH 6.5 is quite satisfactory for all of the elements. This naturally suggests that for optimum crop production in humid regions, the soil should be limed to bring the pH up to 6.5. Unless these soils are limed, maximum benefit can not be obtained from any fertilizer that may be applied.

EXCHANGEABLE HYDROGEN PROVIDES A GOOD MEASURE OF THE LIME REQUIREMENT OF A SOIL

The quantity of lime required to raise the pH from 5.0 to 6.5 is not the same for all soils. For example, 550 pounds of limestone are required per acre to raise the pH of a Sassafras sand from pH 4.5 to 6.5 while 7400 pounds are required to effect the same change in case of Penn silt loam. Such a situation is due to the fact that a Sassafras sand has a very low base exchange capacity as compared to a high exchange capacity in a Penn silt loam soil. Although pH gives an indication as to the percentage saturation of the soil with bases, Table 5, it does not give a measure of exchange capacity. However,

the quantity of exchangeable hydrogen in the soil complex provides a good measure of the amount of lime required to properly adjust the pH. Procedures have been developed whereby both pH and exchangeable hydrogen can be measured accurately with a glass electrode pH meter.

Consider, for example, a sandy soil with an exchange capacity of 6 milliequivalents per 100 grams of soil, and a loam soil with an exchange capacity of 12 milliequivalents per 100 grams of soil, both soils at pH 5.0. For soils that follow the relationship shown in Table 5, pH 5.0 indicates approximately 50 per cent saturation with bases. An exchangeable hydrogen determination would show 3 milliequiva-

TABLE 5. RELATIONSHIP BETWEEN BASE SATURATION AND pH

pH	% Base Saturation
4.0	0–20
5.0	40–60
6.0	60–80
6.5	80–90
7.0	100

lents per 100 grams in the sandy soil, and 6 milliequivalents per 100 grams in the loam soil. One thousand pounds of limestone per acre of soil will replace one milliequivalent of hydrogen per 100 grams of soil. Accordingly, the lime requirement of the sandy soil would be 3000 pounds of limestone per acre, and 6000 pounds for the loam soil.

CHEMISTS AND CROP PRODUCTION

Some fifty years ago soil chemists were making complete chemical analyses of soils in an attempt to find answers to soil fertility problems. They reasoned that by comparing the percentages of the various plant nutrient elements in an unproductive soil with those in a normal productive soil it would be a fairly simple problem to ascertain the limiting factors in the unproductive soil. Unfortunately the problem was not that simple, as crops did not always respond to applications of nutrients as indicated by the complete chemical analysis.

The chemists then decided to study the composition of the plants themselves. The thought being that the elements limiting plant growth would be found in smaller amounts than in normal plants. Again, their efforts were not too fruitful, as they assumed that plants absorb elements from the soil in the exact proportion to which they are required for normal growth. Such is not the case. If the soil permits, plants may absorb a much larger amount of a given element than is actually needed. Furthermore, a deficiency or excess of one

element may substantially alter the quantity of another element absorbed. Then too, plants do not always show a low percentage of a certain nutrient in limited supply, but instead make less growth, thereby keeping the chemical composition of the tissues approximately constant.

Perhaps the oldest and most reliable method for determining the productive capacity of soils and their need for supplemental plant nutrients are the field-plot experiments. However, such experiments are slow and costly, and as a result do not have widespread application. It became imperative that agriculturists have some relatively rapid method for determining the productive capacity and nutrient deficiencies on individual farms. Within the past 15 years, such an approach has come through the development of the so-called rapid chemical soil and tissue tests. These tests are not designed to measure the total quantities of nutrients in the soils or plants, but rather those quantities that are available for plant growth. Although there are certain inherent shortcomings in these rapid tests, when properly applied and interpreted they provide a fairly reliable method for determining the nutrient requirements of soils and crops.

Status of the Major Plant Nutrients—Nitrogen, Phosphorus, and Potassium

Nitrogen, is an integral component of protoplasm and is, therefore, essential for the normal growth and metabolism of plants. It is sometimes spoken of as a regulatory element, since by controlling the supply available, plant growth can be fairly well controlled. High levels of nitrogen in the soil favor rapid foliage growth at the expense of root growth, retards flowering and maturation of plants, and in general results in a soft succulent growth. As the nitrogen supply declines, plants become stunted, the leaves turn light green and gradually yellow.

Nitrogen exists in the soil largely as a constituent of organic matter. This organic matter is decomposed by microorganisms, and the nitrogen converted to nitrates (NO_3), the form most readily utilized by green plants. Since nitrate production is dependent upon the decomposition of the organic matter by microorganisms, whose activity is greatly influenced by aeration, moisture, and temperature, the nitrogen supply may be extremely variable during the course of a single growing season. Therefore, when attempting to determine what supplemental nitrogen should be added to produce a good crop, one must consider the organic matter content of the soil, the possibilities for nitrate production, and finally the particular crop to be grown. There is considerable variation in the nitrogen requirement of different crops.

Phosphorus, enters into the formation of phospholipids and nucleic acids. A deficiency of phosphorus may interrupt the synthesis of these compounds and thereby retard cell division, in the meristematic tissues. Phosphorus favors root growth, and the development of fruits and seeds in the mature plant.

In the parent soil material phosphorus exists as a component of the mineral apatite. As the parent material weathers, the phosphorus is freed from combination with apatite, and combines with other elements to form secondary phosphorus bearing minerals. Since the quantity of apatite is low in most soil forming rocks, it naturally follows that most soils are low in phosphorus. As phosphorus is released in the soil, either from the primary and secondary minerals, organic matter, or from supplemental fertilizer application of phosphorus, a portion of it is bound by the clay particles. As a result of this immobility very little phosphorus is lost from the soil by leaching. If the pH of the soil is below 6.0, insoluble iron and aluminum phosphates are formed, which are very slightly, if at all, available for plant growth. At pH 6.5 to 7.0 the phosphorus occurs in the soil as water-soluble calcium and magnesium phosphates, which are readily available for plant utilization. If the pH exceeds 7.5 then tricalcium phosphates are formed, which are not readily available for plant growth. It is thus apparent that the soil pH is a critical factor in regards phosphorus availability.

With the present soil testing techniques it is a relatively simple matter to test the soil for available phosphorus, and to make the applications of supplemental phosphate fertilizers on the basis of these tests, so that phosphorus need not become a limiting factor in crop production. Of all the plant nutrients obtained from the soil, phosphorus is the most universally deficient.

Potassium, unlike the other ash constituents required in appreciable amounts for plant growth, apparently is not built into organic compounds in the plant. It is required for the formation and translocation of carbohydrates, and appears to function in respiration, but its exact role is still obscure. In general, necrotic breakdown occurs in the lower leaves on plants growing on a soil deficient in potassium.

In the soil, potassium occurs largely in mineral form, and upon weathering the minerals are reduced to clay with a release of potassium. As weathering proceeds, some potassium is always in solution and subject to loss from the soil by leaching, as a matter of fact, there is probably as much potassium lost by leaching as is removed by crops. The potassium absorbed by plants comes largely from the colloidal clay particles in contact with the roots. Potassium deficiency

is more acute on sandy soils because they contain relatively small amounts of the potassium-bearing minerals.

As with phosphorus, the supply of readily available potassium in the soil can be determined by chemical tests, and if found to be deficient, the supply can be supplemented by the proper use of fertilizer.

Status of the Secondary Plant Nutrients—Calcium, Magnesium, and Sulfur

If acid soils are properly limed and fertilized, as indicated by soil tests, calcium, magnesium, or sulfur seldom become limiting factors in crop production. If magnesium is low, it can be supplemented by the use of a high magnesium content limestone.

Status of the Trace Elements

Boron, deficiencies have been found in a number of crops in the Coastal Plain and Piedmont soils of the Southeast, in New England, the Middle West, and the Pacific Coast. Plants have a narrow range of tolerance for boron, the amount required is small, and often times slightly larger amounts are toxic. Borax is the common carrier of boron, and 20 to 30 pounds per acre represents a fairly heavy application, enough to cause injury to some crops on certain soils. Applications as low as 5 to 10 pounds per acre have corrected boron deficiencies on apples and certain other crops. The exact role of boron in plant metabolism is not clearly understood. There seems to be a relationship between boron, calcium, potassium, phosphate, and nitrate availability and utilization.

Copper, is seldom found to be deficient on the mineral soils, but is frequently found to limit yields on muck soils, especially in onion production. Considerable quantities of copper are now being applied in the form of fungicidal sprays for control of plant diseases on many crops, so that it is unlikely that copper will become a serious limiting factor on the mineral soils in the near future.

Iron, is one of the most important of the minor elements, although it is seldom necessary to supplement the supply in the soil. However, iron is applied as an iron sulfate spray to pineapples in Hawaii, and to several crops on the high lime soils in the arid West. Iron occurs as an impurity in most fertilizers.

Manganese, as manganese sulfate, is used quite extensively on citrus and vegetable crops in Florida and the Eastern Seaboard States.

Zinc, as zinc sulfate, has been used in recent years to correct zinc deficiency diseases in corn, pecans, grapes, peaches, and other stone fruits. Its use has been largely confined to the Southern and Pacific Coast States.

Rapid Soil Tests Applied

With the aid of a glass electrode pH meter, the amount of lime required to properly adjust the pH of an acid soil can be readily determined. This is a comparatively simple and rapid procedure, so that widespread coverage of individual farms is possible.

It has been determined by correlation studies between tomato yields grown in experimental test plots and a given rapid soil test for phosphorus and potassium that a soil, in order to produce maximum tomato yields, must contain 180 pounds available phosphorus and 300 pounds readily replaceable potassium per acre. Any soil that gives a lower test for either of these elements, is not capable of producing a maximum yield unless the proper fertilizer is added to correct the deficiency.

As an example of what can be accomplished by a judicious application of rapid soil tests, a case of a tomato grower may be cited. The farmer's soil was analyzed in the laboratory and found to contain 110 pounds available phosphorus and 243 pounds replaceable potassium per acre. This test indicated that in order to meet the nutrient requirements for a tomato crop, a fertilizer application of 900 pounds 3-12-12 per acre would be required. Carefully replicated and controlled experiments on this particular soil gave the following results:

Fertilizer Treatment	*Tomato Yield (Tons Per Acre)*
Check—no treatment	11.64
900# 3-12-12 per acre	20.17

Certainly such tests should be an important consideration in the planning of a sound agricultural program.

Selected References for Further Reading

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The true test of civilization is not the census, nor the size of cities, not the crops—no, but the kind of man the country turns out.—Ralph Waldo Emerson *in his essay on "Civilization."*

Voice amplifier, a portable 12-pound public address system easily carried all day with a shoulder strap, is designed for a guide or instructor escorting a party on indoor or outdoor trips. Complete with battery, the amplifier is attached by cable to the microphone.

FRONTIERS IN TEACHING MATHEMATICS AND SCIENCE*

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The year 1950 finds our social order in the most critical situation in its history. Because of the results of the last World War we find ourselves in the position of Number One nation. The entire social frontier is being challenged by a powerful nation with an ideology quite different from that of the United States. The nation finds itself in its present position because of a number of factors—a great expanse of territory well supplied with natural resources, and a climate suitable for development. Its educational scheme has furnished the nation with 150,000,000 well educated people. A large part of this success has been due to the education of technological leaders in the area of mathematics and science. If the United States has any superiority over other nations it is because of its education and because of the education in these two areas. It is not an accident that the scientists in America have made progress beyond that of other nations. America has a trained personnel, the natural resources, the money and the willingness to carry on research. What will the United States do with this leadership?

With the aid of mathematics and science, Technology has produced a social order organized around an industrialized culture, controlled in a large measure by a corporate society. The United States is a nation of Big Business; this is to our advantage. When we produce much we reduce the price of an individual product. Among the nations of the world we are probably as able as any other to produce what we need. We do it in a shorter time and at less expense. This new culture puts a new demand on our educational organization.

The high school was conceived, set up and organized as a college preparatory school. This was well and good; it served a very valuable purpose, but today people are thinking of a high school program in terms of all the children of all the people. Such a school must be set up in terms of the ability, development and the need of the individual and his social order. It is trite to say that we are living in a scientific age. According to our plan of government all people are charged with the responsibility of taking part. In order to do this within the range of their ability they must be able to do some scientific and independent thinking. General education is a "must" if our type of demo-

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cratic social order is to continue to develop. In this idea there is general acceptance.

When our high schools were organized our national leaders were of the opinion that we needed a few mathematicians and a few scientists. There was no intention of developing scientific and quantitative thinking for the masses. We might ask this question: "Do the masses need more mathematics and science than can be achieved in the elementary school?" The answer which the best thinkers give is, "yes." Quantitative thinking is a natural part of our lives; scientific thinking is also part of our heritage. All need more than they get. In order to discuss these two problems it is necessary to separate mathematics and science and discuss each in turn.

A. *What are the frontiers in the area of quantitative thinking?* Should all high school students have a course in some kind of mathematics? The answer is, "yes." What kind of quantitative thinking is needed? If you casually ask the average person what kind of mathematics people should have invariably he will answer that he needs drills in arithmetic. This answer is very similar to the one which is often given in the area of communication when the question is asked, "What does this student need to enable him to speak and write better?" The answer is, "more grammar." You might continue this question into the other subject-matter areas and get an answer typical of these two.

The high school must continue to give courses in mathematics which will prepare the student for college. The technical colleges want young people with mathematical ability. They do not want to take the time to teach mathematics on the high school level. Mathematics is needed in technology, business, and scientific research. Our high schools are fairly well organized to give this course.

Mathematics for general education. This area has been explored during the past three decades and a number of courses have been set up. Teachers of mathematics and science generally recognize that quantity is a part of life and that it is found in practically every situation. The young man working in the grocery store, driving on the road, in business and in building, finds that mathematics is one of the required learnings. I have already made the comment that many people feel that drill in the fundamentals represents the type of work that should be done. The slow learner is not stimulated much when he tries to make a hundred percent in the four fundamental operations. Fundamental skills need not go beyond the ability of the student to use the skills. We fail to set up a situation where the student feels the skills are needed. Our typical procedure has been to spend a great deal of time building up the skills and then finding a use for them. It would be better if quantitative situations were found, and then have the skills set up to help realize the situation. Much of

our quantitative thinking is done where there is no solution in terms of formula or set quantitative procedure. Yet, we spend so much of our time dealing with the fundamental skills. A new course needs to be worked out in terms of the need and the ability of youth. There are so many situations which make use of quantity that there need be no shortage of material. Select the situations which are as common as possible. Next study the skills that are needed. I have examined many courses of study which have been prepared for the slow learner and feel that much progress has been made, but as yet we have not hit on anything which is very good.

Another difficulty is to find teachers who believe in teaching the slow or average learner. Most of them wish to deal with the college preparatory student. If the course does not have standing with the teachers we may be sure that the students will not accept it. A few years ago a book was published called "Consumer Mathematics." This material was well organized and was set up for all kinds of learners. It could be taught on the senior level to students who had a good stiff course in mathematics. It was also possible to step this material down and make use of the same topics with our slow learners. The frontier which I am trying to discuss is the need for a type of consumer mathematics which is organized in terms of the needs of the learner and in terms of the social order in which we live. Quantity is certainly a part of our everyday experience. There are so many uses which we can make of this quantitative experience that are not featured at all in a modern secondary school.

Since 1920 the Chicago public schools have been admitting to the high school classes young people with less and less ability in dealing with the fundamentals of education. Some schools had eight or ten classes with reading ability from grades four to seven. These people cannot do successfully the standard high school work. In order to take care of this group of students, teachers have been selected who can deal with the three aspects of life—one, quantitative; two, scientific; and three, in that area of English more commonly known as "reading." Teachers with wide experience and interest in young people are now trying to teach the three classes. Their biggest difficulty is to find material which can be read by these young people. This area of the high school is new; we had none of it a few years ago. The question may be asked, "Is there a body of science in which these young people can be interested and which will at the same time be of service to them?" To me, if there is anything in which young people can be interested, it is in some of the vital phases of science. They certainly need the ability to read critically. They certainly need to think through some of the social situations in a more or less scientific manner. The same might be said about mathematics. We cannot af-

ford to permit our young people to finish their high school course without having considerable experience in the field of science and mathematics.

In addition to the frontier found in the area of non-college preparatory mathematics there are also frontiers which need exploring in the college preparatory field. If one studies the contents and method of the first year algebra he will find that it is very similar to that organized in 1890 and very common in 1910 and 1920. I recall using a certain textbook in my first teaching experience along about 1910. It was my privilege to teach this book. This same book is used in the Chicago public schools today with very little revision. The author may point with pride to this book and say that it was so well organized it is still being used; and it might be viewed in another light indicating that no progress had been made during the past few years. There is a tendency in the algebra courses to build around a series of skills. In the particular course which I mentioned if the skills were developed well, there was no time left for application. The skills were developed far beyond anything which first year students would use; also far beyond what any college preparatory student would use. The problem situations are artificial with few exceptions. Would it be possible to take from technology, science, and the economics of government, a series of quantitative situations where algebra could be used in a natural setting? Take these situations, select the skills necessary to understand them and then spend a little time on the skills necessary to build up a logical sequence. During my last years of teaching high school algebra I tried to take problem situations, set up the equation and then set up the skills necessary to understand the situation. In doing this I found that I was better able than before to build up the skills. I well remember teaching a group of adults who had lost out in their high school education. I announced in the first session that all of the four fundamental operations, and the fifth which is factoring, would be taken from a series of written problems. At the close of the class one of the able students came to me and said, "if you plan to do this I might as well quit. I can learn to solve the equations but I never can learn to set them up." What is the value of learning the fundamental skills if we are not able to understand the situations from which these are taken. We have made some progress in this area, but there is still a disproportionate amount of time spent in developing abstract situations apart from the situation in which it is used. The equation should be used to put meaning into a real situation and not the situation to put meaning into the equation. The best teachers of reading teach to learn and do not teach to master the skill of reading. This is learned early in the primary grades. Teaching is used for a very specific purpose. Our mathematic skills should be

used to put meaning into quantitative situations and we should not make use of real situations to put meaning into the skills. This has been one of the weaknesses in American teaching. We learn a series of facts and hunt a place to use them, instead of having a place to use them and then hunt the facts. There is a frontier in our college preparatory mathematics which needs some consideration.

There is another frontier in the teaching of mathematics and that is found in demonstrative geometry. If a teacher tries to teach sixty to eighty theorems during one year's work there is little time left for making any applications. Geometry as well as algebra has been guilty of teaching the fundamental theories without placing them in any real life content. There has been some discussion of teaching the fundamental skills of geometry by having application to real situations, but if the theorems are taught which are outlined in the ordinary textbook there is little or no time left for application. The thinking in geometry is of an adult nature. It was really organized for adult philosophers or for people who wanted to become philosophers. I often wonder why we retain so much of the traditional of demonstrative geometry. To me, a real frontier exists and research is much needed to make better use of the time now spent in the first course in geometry. The proof of these space relationships are of fundamental importance in life. It is doubtful, in my thinking, as to whether or not we are making good use of this year's work. In my pursuit of advanced mathematics I found very little occasion where I would use many of the skills developed in elementary geometry.

Quantitative thinking is a part of life. The teachers charged with the responsibility of developing this ability should make the best possible use of their time. It is recognized that mathematics should be a part of general education. The standard in general education should be the ability of the student. There is also the responsibility of developing mathematicians. In this case the standard should be the one set up in technology, science research, and economics. In other words, the standard should be a college standard.

B. *Frontiers in the teaching of science.* It is commonplace to say that we are living in an age of science. This is often repeated with little or no meaning. Science has made tremendous gains in the area of technology. The quality, quantity, and variety of inventions have amazed the world. Without very much discussion people have accepted the many improvements in the area of technology and in health. The business man seldom questions the advance in machinery or even the advancements made in our great health laboratories; but in general, scientific research has not been applied to any of the various social problems. Technical engineering has made gains beyond all expectations but scientific thinking has never been applied

with any degree of success to the area of human relationships. It is accepted as good practice to make use of scientific thinking and planning in private business, but when planning for a larger social setting it is "taboo."

One of the important phases of scientific investigations has had to do with the new sources of energy. If one follows through the many inventions he will find that as more powerful sources of energy are discovered the fields of human endeavor—production, communication, and transportation—are improved. The success in these fields has been phenomenal, but we are constantly looking for new energy.

"Energy is a determiner of civilization. Low-energy cultures absorb most of their man-power in getting food. High-energy cultures such as the United States, or Western Europe, in recent years, can release more than half their man-power for the service trades, education, and the arts. The atom may release 90 per cent for higher things—if enough higher things can be found. Not 10 per cent will be needed for farming, mining, and manufacturing. Even before the war, learned committees were worrying about the problem of leisure. Presently they are going to have a superlative opportunity to worry!"*

In order to get a little more emphasis on the idea of power I wish to use two other quotations:

"The power until recent date has been molecular, based on natural fuels (coal, oil, moving water), the resources of which are fixed and limited by amount and the supply of which is exhaustible within a short time.

Atomic fission, now successfully completed, revolutionizes the power phase of the productive system, makes available unlimited resources, requires such vast financial support and carries such dangers of monopoly and destruction as to make it probable that power production must be nationally centralized and controlled—possibly world controlled."*

In addition to the various frontiers in the seeking of new forms of energy there are a number of new notions in the teaching of science. A small number of our juniors and seniors have elected botany, zoology, chemistry and physics. Generally only one area was selected because of the shortage of time. Many youth were missing the science so that Boards of Education decided to organize a new course and call it "General Science." The science field is so broad that it is impossible to do very much in one year. General science has been organized and reorganized in an attempt to cover the necessary fields. It is the opinion of many today that general science has served its introductory purpose, and that the secondary school is ready and willing to move forward with a new organization.

Two courses should replace General Science. A biology course should be organized for the ninth grade and a course in physical science for the tenth. The content of these two courses would be selected in terms of their value to the student and community.

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* H. O. Rugg, Foundations for American Education.

What are some of the frontiers that need to be considered in setting up a science program?

1. Many people fail to do any critical thinking. There is a tendency for people to accept what they read in the paper or what some one tells them without doing any thinking whatsoever. This is also true in some of our important social problems. People just fail to think critically about issues on election day. They let their alliance to a political party control their behavior without thinking the problem through. People need to learn to apply some of the scientific methods to everyday problems.

2. The people teaching the science courses have an excellent opportunity to build in the minds of the pupils the idea of health and safety. It is true that during the past few years the span of life has doubled and those being born today may look forward to a span of life undreamed of a few years ago. This has not come about by accident. Our science courses have an excellent opportunity to make practical the teaching of health and safety. Health may come from the courses in biology. Today we are living in the age of fast moving vehicles. The driver and the pedestrian need to understand some of the simple laws of physics. We have a little formula in high school mathematics—distance equals rate$\times$time. Many people never stop to think about how this formula may be applied when driving a car. A person has an opportunity to cross the street as a vehicle is approaching. Will he have time to get across? A car suddenly stops in front of him while he is driving. Is it possible to stop before the cars bump together? We have not only the three variables, distance, rate and time, but the braking service on which the car is rolling must also be considered. Safety depends much on our ability to make quick decisions. To date we have not learned a great deal about living with fast moving vehicles. Recently the Chicago schools have been releasing safety bulletins. These bulletins are written for three different departments. The science teachers are asked to deal with that part of safety which has to do with science. The English teacher assumes the responsibility for building up the right attitude towards human life. The civics department assumes the responsibility for building up an understanding of legislation which has been passed for the protection of the people. One of the important objectives of science is an understanding and appreciation of health and safety.

3. Among the other areas which may be mentioned and not discussed are plant and animal development, communication, transportation and road building, clothing and housing. These areas represent frontiers which might be studied in terms of scientific instruction. Each might be the subject of a long discussion but time will not permit.

In conclusion, I wish to make the following observation: Quantitative thinking and critical investigation should be made a part of general or required education. If a student is interested in anything the activities found in the science course can be organized for him. The standard in general education should be the ability of the student; the standard in college preparatory courses should be the demands of the college and technology. The world is in dire need of workers on a higher level to think in terms of the formula and scientific procedure. If scientific procedures and critical thinking are not applied to the problems of human relationships our social order will take its place with the "has been" nations and a more able one will replace it. The future of our nation is at stake. Success will come as a result of a bombardment of ideas and not as a result of atomic energy.

SCIENCE MANPOWER COMPETITION TOUGH ON ARMED FORCES LABORATORIES

As defense production orders mount up and recent enlarged appropriations for Defense Department research begin to come through, armed forces laboratories are starting to feel the effects of competition from industry for scientific and technical manpower. Private industry can pay more.

A recent example of this, with others like it expected, was the case of an underwater sound physicist at the Naval Research Laboratory. He receives a salary of $7,800 a year. A private concern offered him $12,000. Fortunately, this particular physicist will probably stay with the government because he likes his work.

The pinch is not confined to Ph.D.'s. The Naval Research Laboratory has approximately 3,000 employees, of whom 1,000 are scientists and another 1,000 technicians and craftsmen. The latter build the machines and equipment which are the tools and products of scientific research.

Private industry is beginning to compete for these skilled workers, too. This competition is not confined to defense industry—television manufacturers have made tempting offers to some of the workers at this Laboratory.

Officials at the Laboratory do not know what the answer will be if all-out mobilization hits the nation. The answer will come from a higher level of government. Right now the National Security Resources Board is considering plans which envisage control during all-out mobilization of scientific and technical personnel, but whether or not this will include skilled laboratory workers is another question.

Another worry in this, and other, defense department research operations is the large number of employees in the reserves. Of the 3,000 employees at the Naval Research Laboratory, between 500 and 600 are in one component or another of the reserves.

If a man who is called up wants to go on active duty, the policy is not to ask for deferment. However, deferment has been asked for most employees in the reserve who have been called up. In all cases, except for those who are in Naval Aviation reserve units, this deferment has been granted.

What worries those responsible for keeping up the quality of the research work in the Naval Research Laboratory is, in view of the large percentage of reservists on the staff, what will happen during a total mobilization?

AN ELECTRICALLY ANIMATED PANEL AS TOOL FOR THE TEACHING OF ABSORPTION SPECTROSCOPY

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INTRODUCTION

The scientific implications in so familiar a phenomenon as the rainbow are hardly conceivable. Yet, when man began to probe for the cause of the spectrum, when he hit upon the great cornerstone of spectroscopy—that emitted light is characteristic of the atoms of molecules that produce it—he had drawn a conclusion which was of invaluable consequence. The study of spectroscopy and the invention of the spectroscope have formed the basis for our knowledge of atomic and molecular structure, our knowledge of planetary electrons, and the formulation of the quantum theory of radiation. Moreover, the field of spectroscopy has made possible quick and precise methods for both quantitative and qualitative analysis.

Probably the most spectacular achievement of absorption spectroscopy and one of the greatest tales of international scientific cooperation—was the identification of Vitamin K:

Once upon a time (1931) there lived in Canada a man by the name of MacFarlane. He noticed that chicks, while thriving when fed on a diet of whole fish meal, suffered a high mortality rate and extensive bleeding from small wounds when fed on a diet of ether extracted fish meal. Obviously there is a great number of substances, like fats, etc., removed from the fish meal through the ether treatment and the high mortality rate is therefore not too amazing. In 1935, however, Dr. Dam in Denmark was able to stop the "extensive bleeding" of these chicks by adding to their diet a certain fat-free part of the substances found in the ether extracts of fish meal. Dam called these unidentified substances "antihemorrhagic principle" or "coagulation vitamin." This essential fraction of the diet is now known as "K."

Antihemorrhagic substances are, of course, of highest interest and a great number of scientists in many lands started to work on the identification of this coagulation vitamin. The chemical literature of the years 1935–39 is interspersed with small but significant contributions to the understanding of the properties of these "K" fractions. Outstanding among these publications are those from the University of California, St. Louis University, and from the pharmaceutical laboratories of Squibb and Merck. Among various characteristics of

the antihemorrhagic principle, it was noted that its solutions showed strong absorption of ultraviolet light of the wave length of about 2,500 Å. Comparison of the absorption curves of the unidentified antihemorrhagic principle with the absorption curves of some known substances, led a group of scientists from Harvard and Northwestern University to the following statement: ". . . From the similarity of Vitamin K in absorption spectrum . . . it is probable that this substance is . . . a 2,3-dialkyl-1,4-naphthoquinone . . ."[1]. Administration of extra doses of Vitamin K was then made part of the preoperational treatment of patients.—Mankind was fairly safe from hemorrhages ever after.

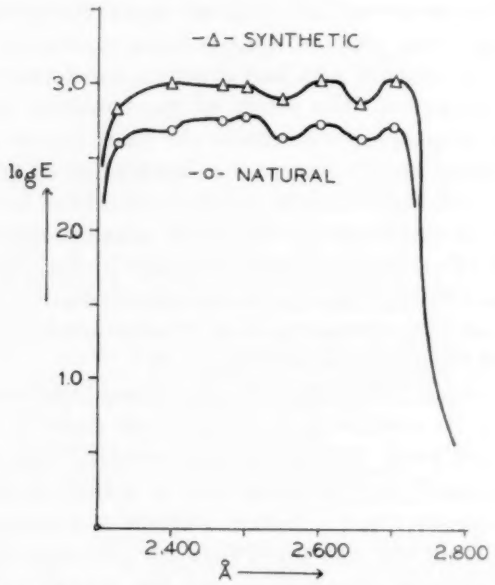

FIG. 1. Absorption of light by 1% solutions of natural and synthetic vitamin K.

Fig. 1 shows the absorption curves of the extracts from natural sources, which contained the then unidentified anti-hemorrhagic principle, and the absorption curve for the then known synthetic compound. Such curves do not only give qualitative information regarding the chemical nature of the compound (wave length of maxima and minima), but also quantitative data regarding the concentration, of which "E" is a function.

When the absorption curves of the pure components are known, absorption spectroscopy can be used to determine the components in a mixture quantitatively.

[1] Fieser, Louis F., et al.; *J. Am. Chem. Soc. 61*, 1925 (1939).

Such computations are in theory extremely simple:

$$C^A = \frac{E_{\lambda_2}{}^{\text{total}} K_{\lambda_1}{}^A - E_{\lambda_1}{}^{\text{total}} K_{\lambda_2}{}^B}{K_{\lambda_2}{}^A K_{\lambda_1}{}^B - K_{\lambda_1}{}^A K_{\lambda_2}{}^B} . \qquad [1]$$

Actually the number of indices on the variables is confusing to the beginner, especially when not accompanied by experimentation. Un-

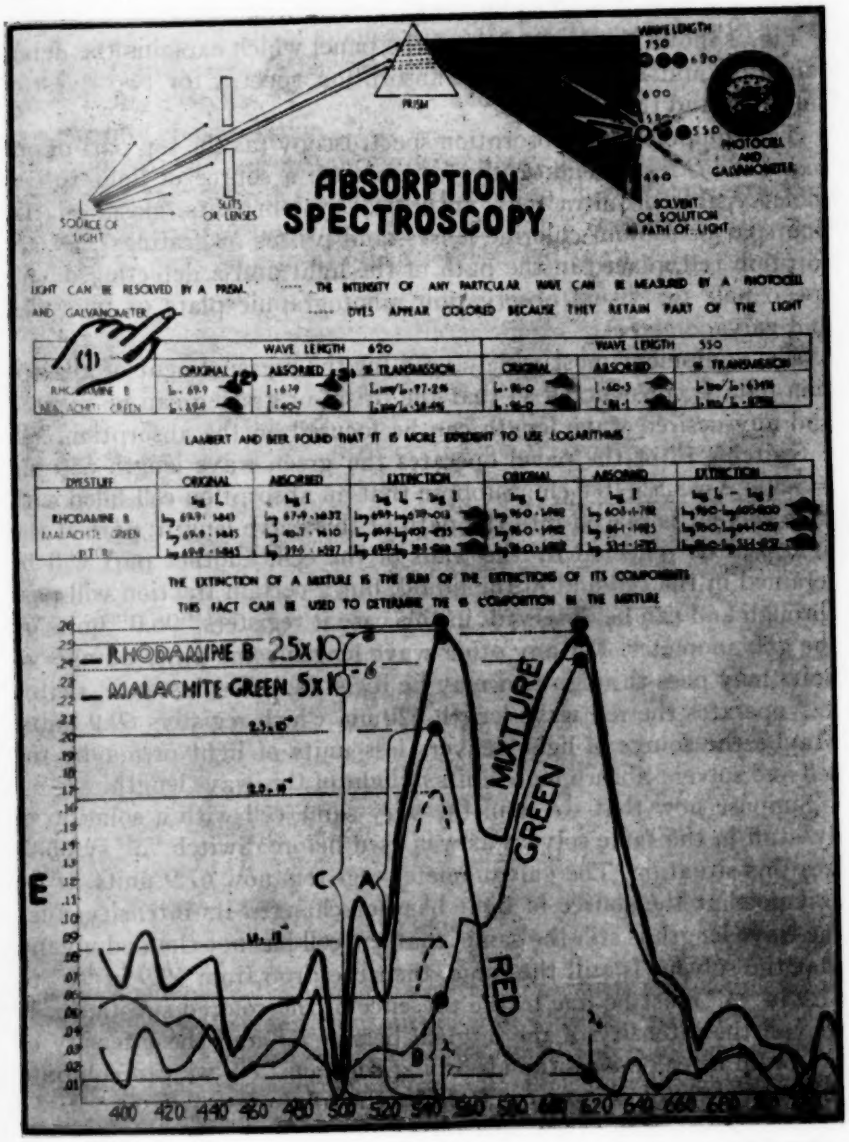

FIG. 2

fortunately, the experimental determination of absorption curves is too time consuming to be used as lecture demonstration.

The Panel as Teaching Tool

We have tried to capitalize on one of the greatest gifts of the human intellect, its capacity to use symbols. An electrically animated panel[2] was constructed and used in conjunction with the demonstration of some actual equipment.

Fig. 2 shows the front view of the panel which explains the determination and computation of absorption spectra for two dyestuff solutions and their mixture.

The equipment for absorption spectroscopy (as the top part of our panel indicates schematically) consists of: a source of light (ultraviolet visible or ultra red), an optical system (slits, glass, quartz, fluorspar or sodium chloride lenses, and prisms or gratings), an absorption cell, placed in the path of the light and a detecting device (peep hole for visual observation, photographic plate or photocell and galvanometer).

The equipment most widely used for the measurement of absorption data is constructed so that the prism or grating can be rotated and any desired wave length can be focused on the absorption cell.

Switch "1" of the panel operates the green wave length 550 mμ = 5,500 Å = 5.5×10^{-5} cm. Suppose that an absorption cell filled with pure solvent is placed into the path of this wave length: part of the light will be reflected by the walls of the cell, another part will be retained in the cell and in the liquid, but a certain fraction will pass through and can be observed: in this case it registers "96.0" units on the galvanometer. For any other wave length some other number of units may pass through and may be registered. For instance, switch "2" operates the red wave length 620 mμ which registers 69.9 units. Maybe the source of light delivers less units of light or maybe the cell and solvent absorb more units of light of this wave length.

Suppose now that we refill the very same cell with a solution of dyestuff in the same solvent as was used before. Switch "3" symbolizes this situation. The galvanometer registers now 67.9 units. If we assume that the source of light has not changed its intensity, that the wave length is still the same, that the cell has not clouded up and that the solvent is still the same, then the drop from 69.9 in "2" to 67.9 in "3" must be due to the presence of the colored substance. If we call the intensity of the original beam "I_0" and the intensity of the beam after passing the absorbing solution "I", we can compute the percentage of light transmitted by the solution:

[2] Over all dimensions 38×48 inches.

$$\%T = \frac{I \times 100}{I_0}$$

or inserting our data

$$\%T = \frac{67.9 \times 100}{69.9} = 97.2 \cdot$$

This red dyestuff transmits practically all of the red light.

Switch "6" and "7" symbolize the data for the wave length 550 m. (63.0% transmission). The red dyestuff transmits very little of the green light. Switches "4," "5," "8," and "9" represent data taken on a malachite green solution.

The observed transmittancies depend, of course, upon the concentration of the colored substance in solution: higher concentrations give lower % transmission. Data taken for a certain solution at a number of wave lengths are then represented as curves (% T versus λ). See Fig. 3.

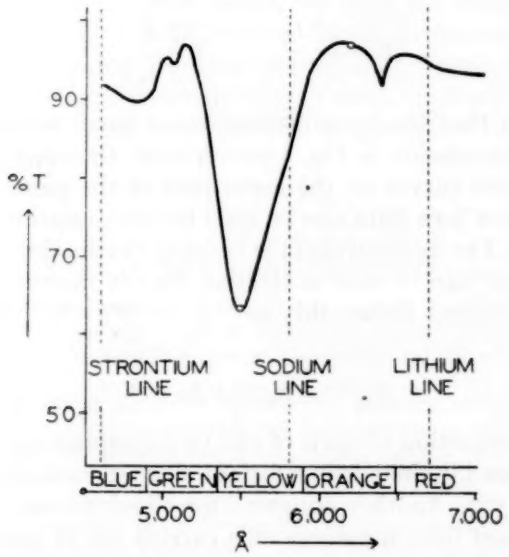

FIG. 3. Per cent transmittancy of a 2.5×10^{-6} M solution of Rhodamine B in water.

The Rhodamine B curve shows little transmittancy of green and yellow light, but strong transmittancy of blue and red: the color of the solution is a bluish red. The concentration in solution has to be chosen so that even the small transmittancies are still observable. In other words, the weaker the source of light, the more dilute has the solution to be.

The % transmission data can not in themselves be used for the computation of concentrations. Higher concentrated solutions give less transmittancy, but the relationship is logarithmic:

$$\%T = \frac{100}{10^{Kcd}} \quad \text{or} \quad \log T = 2 - Kcd$$

where "K" is an empirical constant for each wave length, "c" is the solute (dyestuff) concentration and "d" is the thickness of the layer of dyestuff solution.

Lambert and Beer, who have detected this logarithmic relationship, use it for convenience in this form:

$$E = \log \frac{I_0}{I} = \log 10^{Kcd} = Kcd \cdot \qquad [2]$$

E is called extinction. I_0 = intensity of beam after passing pure solvent; I = intensity of beam after passing solution. Comparing extinction (E) with transmittancy (T).

$$E = \log \frac{I_0}{I}, \qquad T = \frac{I}{I_0}$$

It can be seen that big transmissions mean small extinctions. Minimum of % transmission in Fig. 3 corresponds, therefore, to maximum of the extinction curves on the lower part of the panel. Switches 10 through 15 show how data can be used for computation and plotting of extinctions. The main advantage of using "extinctions" rather than "transmissions" can be seen in the fact that in mixtures of the components. The panel shows this as "A"+"B"="C" or more adequately

$$E_{\lambda_1}{}^{\text{mixt}} = E_{\lambda_1}{}^{\text{red}} + E_{\lambda_1}{}^{\text{green}} \cdot \qquad [3]$$

If the concentration of each of the two components is to be computed, equation [3] alone is insufficient since it contains 2 unknowns $E_{\lambda_1}{}^{\text{red}}$ and $E_{\lambda_1}{}^{\text{green}}$. Another equation for simultaneous use can however be obtained from measurements carried out at some other wave length[3] and inserted in equation (1).

Constructional Details

Based on the experimental data determined in this laboratory, the essential details of the face of the panel were laid out on paper. The spaces for the electrical switches, pilot lights, galvanometer, etc. were marked and then drilled through a $\frac{3}{8}$ plywood panel, the edges of which were reinforced by a wooden frame (1 in. × 3 in.).

[3] See for instance Gibb, Thomas R. P., *Optical Methods of Chemical Analysis*; McGraw-Hill, New York, 1942.

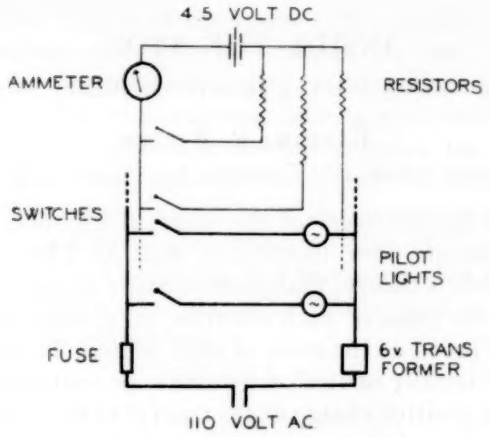

FIG. 4

Fig. 4 shows a schematic sketch of the wiring. Essentially it is a 6 Volt AC system for the pilot lights, fed from the Edison Line via a transformer, and a $4\frac{1}{2}$ volt DC system for the galvanometer, fed from a dry cell in the panel. Suitable galvanometer deflections are produced by connecting to properly chosen series resistors. The switches are of the self returning, multiple pole single throw type as used by the radio industry.

SCIENCE TEACHERS FELLOWSHIPS

Science Teachers Fellowships provided by a grant from the Westinghouse Educational Foundation will bring 50 high and preparatory school teachers of science to the Massachusetts Institute of Technology for six weeks beginning on Monday, July 2, 1951.

Designed to provide a review of fundamental sciences as well as a survey of recent scientific advances, the program will include lectures and demonstrations by many prominent members of the M.I.T. faculty. It will be under the general direction of Professor Francis W. Sears, chairman of the Institute's Summer Program for Science Teachers Committee.

The fellowship program is made possible by a grant of $62,500 from the Westinghouse Educational Foundation, made in 1949 to provide 50 M.I.T. Science Teachers Fellowships of $250 each to be awarded each summer from 1949 to 1953.

The 1951 program, third in the five-year series, is open to science teachers in high and preparatory schools throughout the United States who are college graduates or have equivalent qualifications to carry on the courses. Applications must be made by April 1, 1951.

The program will include a review of important concepts in physics and chemistry presented by those in charge of freshman instruction in these subjects at M.I.T., and will cover recent developments in the fields of physics, chemistry, biology, meteorology, geology, and aeronautical engineering. The summer program will begin with registration on Monday, July 2, and will continue through August 10.

INSIDE THE ATOM

V. MORE ABOUT WHY THE ATOM NEEDS NEUTRONS

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Even before the discovery of the neutron, scientists knew that all un-ionized elements were electrically neutral. They assumed, too, according to Bohr's theory, that protons made up most of the mass of any element, the mass of each electron being only about one two-thousandth as much as the mass of each proton. In order for an element to be electrically neutral, scientists supposed that for each proton (carrying a positive charge of electricity) in its make-up, it would have somewhere in its structure an electron (carrying a negative charge of electricity). It was known that hydrogen, the simplest and smallest of all atoms, had a nucleus of a single proton, and that that proton had a mass 1840 times as great as the mass of an electron. This proton accounted for practically all the mass of the hydrogen atom. It formed the nucleus of the hydrogen atom and carried a positive charge of electricity. The positive charge balanced the negative charge of the one electron in the outside ring of the hydrogen atom.

The nucleus of each atom, in the same way, was expected to contain enough protons to account for the weight of that atom, since the weight of the electrons revolving around the nucleus at quite a distance from it is so little that it would take 1840 electrons to weigh as much as one proton.

However, this theory didn't quite fit. It was known, from the chemical behavior of certain elements, that there were fewer electrons, or negative charges, in some atoms than there would have to be positive charges if protons made up all the weight of the atom. In other words, if a hydrogen atom had 1 electron and a chlorine atom had 17 electrons and a uranium atom, the heaviest atom known, had 92 electrons,* then, in order to balance those negative charges, a hydrogen atom would have to have one proton (and it does), a chlorine atom would have to have 17 protons and a uranium atom, 92 protons. But a chlorine atom actually weighs over thirty-five times as much as a hydrogen atom, so it must, the scientists thought, have 35 protons. And a uranium atom weighs over 238 times as much as a hydrogen atom, so that scientists assumed that it must have that many protons.

If a uranium atom were going to have 238 protons and continue to balance electrically, there would have to be 146 electrons hiding

* And these are the actual numbers of electrons that scientists have decided that hydrogen, chlorine, and uranium have.

somewhere in the nucleus of the atom. (They couldn't be anywhere outside the nucleus or they would change the way the atom was known to behave, for *chemical valence*, which determines with what other elements, and in what amounts, a certain element will combine, is determined by the number of electrons outside the nucleus of an atom.) In the same way, chlorine would have to have 18 electrons hidden, and other atoms would have to have electrons in various numbers hidden in their nuclei. For a number of years, before the neutron was discovered, scientists had to assume that the extra electrons required to balance the atom electrically must be hidden somewhere in the nucleus of the atom.

MAKING AN ABACUS

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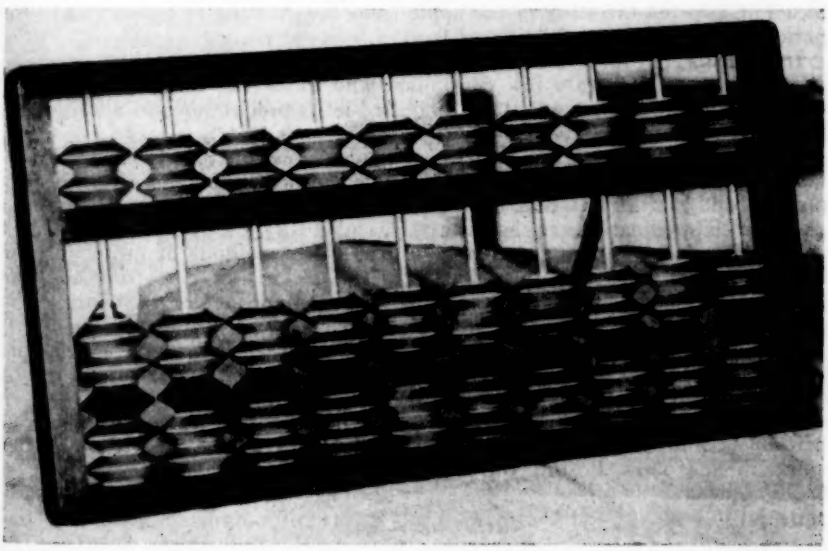
Hofstra College, Hempstead, New York

It is possible to purchase (in New York City's Chinatown) a commercial abacus for about eight dollars. However, a completely satisfactory instrument can be made easily using very inexpensive materials. The device illustrated uses beads discarded by the proprietor of a billiard parlor. These beads, originally designed to be used in keeping a billiard score are uniformly turned from hard wood and



are ideal. If such beads are obtained second hand, they probably will be very dirty and it may be necessary to refinish them. The old finish is particularly hard but soaking in paint remover will loosen it. Some

of the beads are black and some are natural maple. The black beads have been very thoroughly stained and it is not feasible to remove the stain. The beads used in my abacus were obtained through the efforts of a student who had not previously shown any interest in "matters mathematical."

The wires on which the beads are strung should be straight. Wires which have been bent (or coiled) should not be used. The wires should be of as large a diameter as is consistent with free motion of the beads. Unbent wire of the necessary size is not difficult to obtain. The wires used by florists to support plants, the bottom sections of wire coat hangers, or welding rods may be used.

The dividing section of the frame should be drilled first and then clamped successively as a jig to each of the two side pieces to assure that the holes are in alignment. The holes for the wires should not extend through the sides. The wires should be set above the center of the frame so that the beads will more freely when the abacus is placed flat upon a table and that with the instrument in this position the beads will extend above the top of the frame for ready manipulation.

THE APPLE FILM

The apple, the most widely cultivated fruit in the temperate zone, is the star of a new full color educational motion picture released by Encyclopaedia Britannica Films to tell the story of the apple from the planting of the tree until the packing and shipping of the ripened fruit.

In its marketed form the apple is possibly the most widely known fruit to Americans, but there are few consumers who know the complex operations, human effort and technological skill required in its production and distribution. In APPLES (From Seedling to Market) this story is told.

The film was made in the Wenatchee Valley, Washington. Following panoramic scenes of producing orchards the film shows the complex operations of planting and grafting. Pruning operations are illustrated and methods of natural and artificial pollination are shown.

The film shows spraying and dusting and other methods of protecting the fruit and trees. The film then illustrates the picking of ripe fruit and the processes of sorting for quality and size and preparation for shipping in the packing house.

The one reel, full-color 16 mm. film is intended for use in primary and middle grades in geography, social studies and home economics classes, by adult groups and farm associations.

APPLES (From Seedlings to Market) may be purchased from Encyclopaedia Britannica Films, Wilmette, Illinois, or rented from any of the eight regional offices in New York, Boston, Birmingham, Michigan, Chicago, Atlanta, Dallas, and Pasadena.

Casement windows for houses are cast in a single unit and have no welded or other joints. Casting in this form is made possible by a new type of permanent mold. Increased strength and rigidity is one advantage while rounded corners make cleaning easier.

THE MOON FOR FIFTH GRADERS

LILLIAN PUTNAM AND STANLEY RUSSELL
Shady Hill School, Cambridge, Mass.

In our school science is first taught as a special subject in the fifth grade. Prior to this the children have had many excursions into science with their room teachers or through our new Lower School science center. In the fifth grade, however, the children come to science class daily for one half hour. Since textbooks are not used, it is possible to have a flexible program which can vary with such factors as seasons, particular interests of a group, items of special interest which the children may bring in, or natural phenomena which may occur.

Our study of the moon comes into the last category since it began with the study of the total eclipse of September 25, 1950. It has been a continuing but not continuous activity, for we have also taken time to examine birds which were brought in after flying into picture windows, snakes found on the walks at school, turtles and slugs, and have learned how to read a thermometer in the course of our observations of the weather. This method has been used to enable us to discuss the moon over a period of time long enough to make it possible to observe the moon in different phases, so that our discussions are to a great extent supported by the experiences of the children, rather than the authority of the printed word. Also, the side trips into other material have kept the children's interest high, which might not be the case in a continuous study.

We began the study of the moon with a discussion of the approaching eclipse, for newspaper publicity had made many people aware of it. Through the discussion children were able to offer explanations of what an eclipse looked like, what caused an eclipse, when they had seen or heard of one before. With the aid of a timetable for the event, it was suggested that the children, if possible, arrange with their parents to be awakened in order to see it.

In spite of the hour many children were able to observe the eclipse and subsequent class periods were used to examine the appearance of an eclipse based on first hand observations. The observers were only too willing to draw sketches on the blackboard to illustrate their descriptions. This also provided an opportunity to note discrepancies in some illustrations concerning the position of the shadow. The point was well made that there is a difference between "looking" and "seeing," and that accurate observations are of great importance in science.

A simple set-up was used to re-enact the eclipse in the classroom.

On one end of the long desk at the front of the room was placed a ring-stand supporting a reflector flood-lamp. The lamp faced the opposite end of the desk, and on the desk were placed a large globe and a small globe. The children were quick to volunteer the information that the light represented the sun, and the globes the moon and earth. They were then asked if any of them could place our moon and earth in the correct positions which would cause a lunar eclipse. The teacher did not attempt to stop any child from placing the globes incorrectly, but instead led the class into careful consideration of the results of any particular arrangement. In one case, where a child arranged the globes in position for a solar eclipse there were two children who were able to point out the error and call it a solar eclipse.

When the arrangement was correct it was recalled that the moon had been full that evening, and by moving the moon out of the earth's shadow it was possible to see clearly how a full moon came to be, and why a lunar eclipse occurred only during a full moon. With a minimum of didactic teaching the question of relative sizes and distances was introduced and studied by means of a simple scale diagram of the earth's shadow which was constructed of string on the front wall of the room. With a scale of one inch to four thousand miles the earth and the end of its shadow were almost at opposite ends of the room, while the moon, represented by a thumbtack was between them, passing through the earth's shadow. However, the sun was not on the diagram, and in reply to the question of one child, the teacher explained that it would have to be represented by a huge ball about sixteen feet in diameter and almost a half mile away. Using another scale several strings were prepared, each representing the radius of the sun. Each string had a small loop at one end which was dropped over a nail in the floor in the center of the room. Each child held one string and, with a piece of chalk at the free end drew a small arc on the floor. The result was a huge circle made up of all the arcs. To the same scale, the earth was represented by a one inch disc of paper. This was placed inside the sun circle to give a better idea of the comparative sizes.

Because textbooks are not used, notebooks are kept by the children to become, in effect, textbooks which they have made. In these notebooks are kept word lists, a daily record ("Sept. 25: Total eclipse of the moon"), and diagrams. After the foregoing material had been covered and tested, the class began working on a simple diagram of an eclipse. The diagram was first worked out by the teacher on the same unlined notebook paper the children would use, with careful attention given to ease of construction. We have found that even at this level children can do neat and accurate work if they are guided step by step. To be sure, there is a certain uniformity and lack of

individual expression, but the purpose of the diagram is to provide an accurate, understandable record of what took place. Constructing the diagram recreates the learning experience that has preceded it, and, in addition, is a practical exercise in using a scale, as well as hand skills. Fig. 1 is the diagram which was used.

Some time later the weather was clear and the moon in third quarter was visible during class time. It was observed with a telescope as well as the naked eye and an entry made in the daily record. Using the same set-up of two globes and a lamp, this change in appearance was worked out in class.

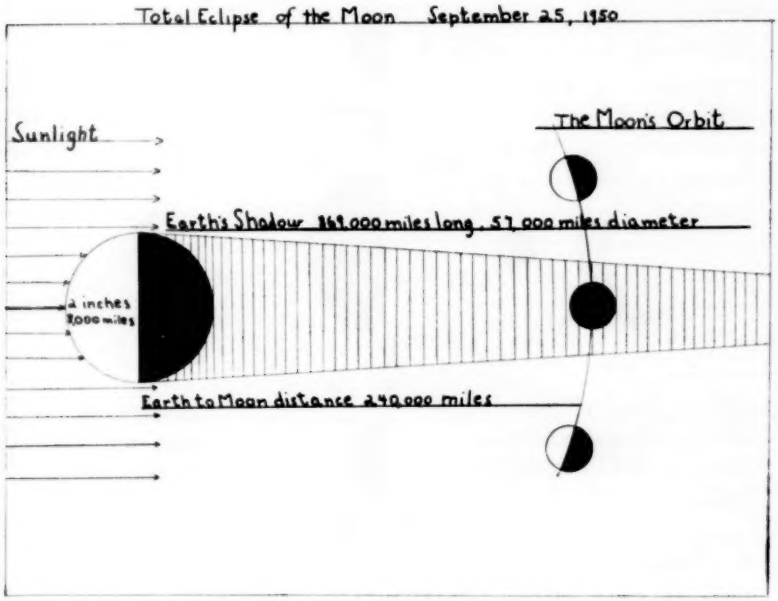

Total Eclipse of the Moon September 25, 1950
Sunlight
The Moon's Orbit
Earth's Shadow 869,000 miles long, 5,000 miles diameter
8 inches
8000 miles
Earth to Moon distance 240,000 miles

FIG. 1

Later on when the moon was in first quarter the subject was brought up again. Children who had seen it drew their impressions on the blackboard. This brought up the question: "Which way is it curved?" It was suggested that the appearance depended on the time it had been observed, but one girl had seen it at two different times the same evening and it looked the same each time. Reference was then made by the teacher to the daily record and our previous observation. The questions before the class then were, which was the correct picture? Were there two or more moons? One suggestion was that the calendar would tell, because it always had pictures of moons on it. Finally two globes and a lamp were brought out and the movements of the moon worked out.

This was a more detailed study than the previous one, because a new observation had been made in addition to change of shape: the third quarter had been seen in the morning, but the first quarter had been seen in the evening. Why? With the globes and lamp in place, a day-night line could be seen on our earth. The new moon position was in the *middle* of the night area, but the first quarter was at the *beginning* of the night area and the third quarter was at the *end* of the night area. This was a difficult idea to grasp, but the children had the evidence of their own observations to help them. Also, it was not

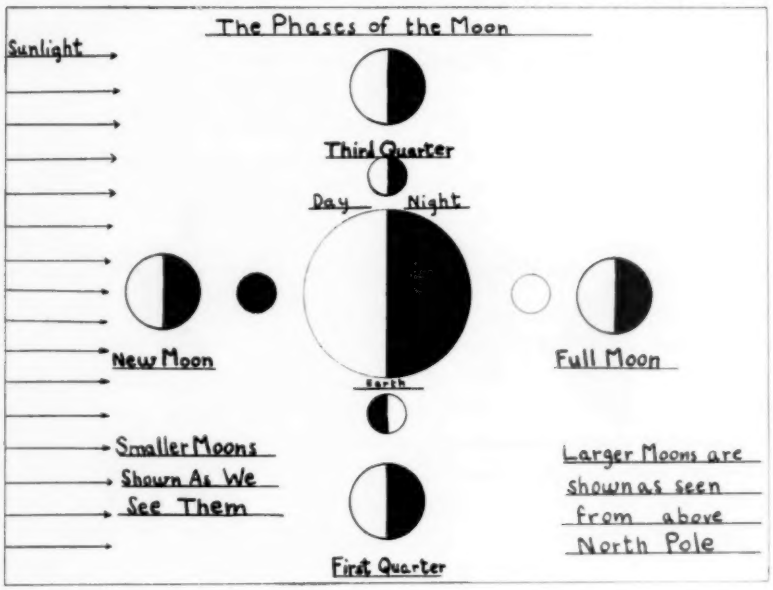


FIG. 2

easy to determine the appearance of the quarters, for although our model showed clearly that when the moon moved we saw differing amounts of the lighted area, it showed the entire sequence from a point in space, not from where we would be looking on the earth. As a result, the appearance of the first and third quarters was reversed. To aid in overcoming this the children were encouraged to move about and try to see the lighted moon-globe from the earth side. When these ideas had been fully examined and there was evidence that the children had a good grasp of them another diagram was begun. This one was not to scale, for the emphasis was on the phases of the moon. In order to help the children understand that this diagram is drawn as the earth and moon might appear from a point above the north pole, the globes and lamp were first placed on the floor in the center of the room to enable the children to look down on

them. Also, the small images of the moon's phases *as we see them* were included in the diagram to relate *what happens* with *what we see.* See Fig. 2.

The use of simple equipment which the children can manipulate is a key factor in our program. Even the globes which were used were changed from time to time. Once the earth was represented by a common terrestrial globe; another time it was a celestial sphere with stars on it. But it was a round object and the children could manipulate it. Special equipment may be constructed or purchased which will more faithfully reproduce an actual phenomenon, but often the children become so intrigued with the equipment that they lose interest in the concepts involved.

In this brief account only the highlights of our moon program are represented. A great wealth of material can be included in the daily class planning, ranging from discussions of the movie "Destination Moon," to the curved eclipse shadow as evidence that the earth is round. We have felt that by giving the child an opportunity to learn from his own experience where possible, the understanding of the basic concepts becomes strong enough to make an imaginary trip to the moon less of a fantasy and more of an extension of understanding.

ANIMAL STORIES

Appealing full-color drawings depict delightful animal adventures in a new series of six discussional slidefilms entitled *Animal Stories*, produced by The JAM HANDY Organization. Designed for primary children, each film contains the attributes of a good story—a plot leading up to the climax, repetition, action, conflict, and suspense.

The six films in the series are: "Rings, the Raccoon"; "The Lazy Bear Cub"; "Brush, the Red Squirrel"; "Mrs. Cackles Becomes a Good Citizen"; "Hoppy, the Rabbit"; and "The Adventures of Pete and His Dog."

The six slidefilms in the series are available in an attractive kit box for $23.40. Individual films may be purchased for $4.20. *Animal Stories* may be obtained from The JAM HANDY Organization, 2821 East Grand Boulevard, Detroit 11, Michigan, or its distributors.

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DEMONSTRATION EXPERIMENTS IN PHYSICS

WALLACE A. HILTON
William Jewell College, Liberty, Missouri

Three demonstration experiments in physics that have been suggested by Roberds,[1] Christensen,[2] and Mackay[3] are of such a nature that they can all be assembled as one piece of equipment that will take up less than a two-foot square of floor space as shown in Fig. 1.

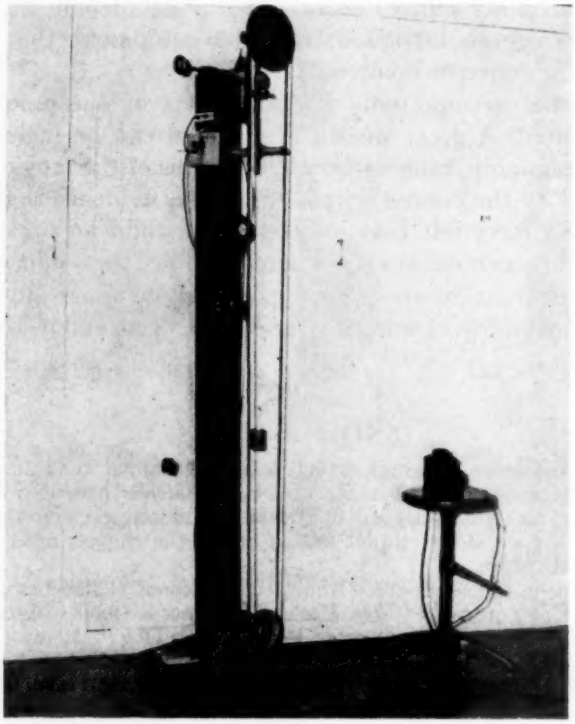

FIG. 1

The falling body apparatus as proposed by Roberds[1] makes use of a Cenco impulse counter which records the time for a steel ball to fall through a certain distance. In Fig. 2, the counter (C) is operated from the transformer (T) and reads to 1/120 of a second when used on 60-cycle current. When the key (K) is closed the voltage drops below the value necessary to operate the clock. When the spring (S) is released, the ball (B) begins to fall and the counter starts. It continues until the circuit is broken by the ball when it strikes the

[1] W. M. Roberds, *American Physics Teacher*, Vol. 5, p. 228.
[2] F. E. Christensen, *American Journal of Physics*, Vol. 16, p. 248–249.
[3] R. S. Mackay, *American Journal of Physics*, Vol. 16, p. 248.

spring (S′). In our case the distance is 170 cm. and the error is less than 3 %.

The transverse-wave apparatus as developed by Christensen[2] consists of an endless belt running over two pulleys, the belt in this case consisting of rubber tubing filled with sand. The lower pulley

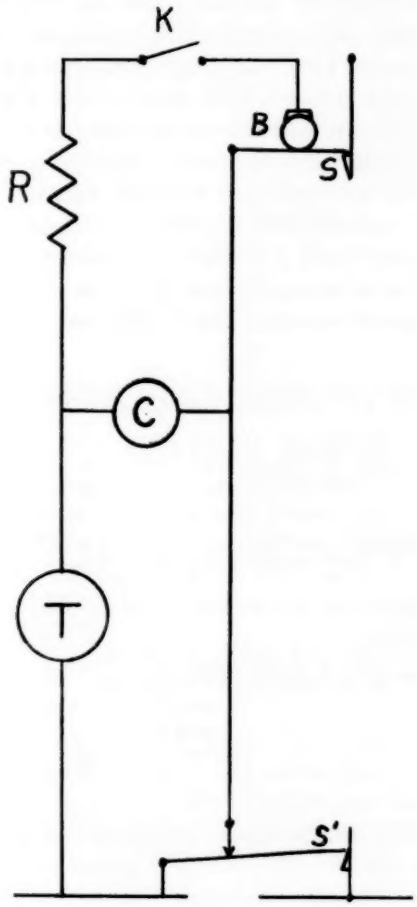

FIG. 2

is attached to an electric motor and the speed is controlled by varying the applied voltage. The other pulley is placed about 7 feet above the lower one. The speed of the motor is adjusted so that when the slack side of the belt is given a quick tap just below the upper pulley, the wave form moves slowly down the belt. This demonstration proves helpful when developing the formula for the velocity of a wave on a stretched string.[4]

[4] M. Y. Colby, *Sound Waves and Acoustics*, Henry Holt, 1938, p. 81.

Mackay[3] has proposed a solution for the "climbing monkey" problem which is used as the third experiment for this piece of equipment. The problem involves a monkey hanging from a rope that passes over a frictionless pulley to a coconut that has the same mass as the monkey. The problem is to determine what happens when the monkey starts to climb the rope. In this apparatus, a steel yo-yo represents the monkey and a tin can filled with paraffin and lead shot symbolizes the coconut. Two ball-bearing pulleys approach a frictionless pulley, and a light string is used for the rope. Part of the string is wound around the yo-yo and the remaining part is placed over the pulleys with the remaining mass on the other side. With both masses at the same height, the system is released and both the "monkey" and the "coconut" fall and rise together.

In Fig. 1, the falling body experiment is shown at the center of the picture, the standing wave apparatus is to the right and front; while the "climbing monkey" experiment is to the rear and to the left.

NOTICE TO OUR READERS EVERYWHERE

I am doing a little "advertising" for the JOURNAL and I need your help in an elementary way. In order to demonstrate the tremendous geographic spread which SCHOOL SCIENCE AND MATHEMATICS has I want to put on a public display of envelopes received from readers throughout the world. The cost to you individually is quite negligible—a minute or two plus a postage stamp. The profit to the JOURNAL may be quite substantial. Accordingly, will you kindly do the following right away:

1. Address an envelope *to me* in your own hand.
2. Post it at once.
3. Write a note if you wish, but this is not necessary.

An abundant New Year to you, wherever you are.

JULIUS SUMNER MILLER
Physics Editor
Dillard University, New Orleans 22, La.

EVERYDAY ELECTRICITY CHARTS RELEASED BY WESTINGHOUSE

A set of eight wall charts showing the construction and operation of familiar electrical devices has been released by the School Service Department of the Westinghouse Electric Corporation.

By the use of drawings and caption material, these *Everyday Electricity Charts* give a detailed description of the automatic washer, electric iron, electric motor, electric range, electric refrigerator, fluorescent lamp, incandescent lamp, and vacuum cleaner. They are printed in two colors on heavy white glossy paper, and each chart measures 25 inches by 38 inches.

The charts can be obtained at a cost of $1.00 per set by writing to School Service Department, Westinghouse Electric Corporation, 306 Fourth Avenue, Box 1017, Pittsburgh 30, Pa.

You give but little when you give of your possessions. It is when you give of yourself that you truly give.—Kahlil Gibran

EMERITUS LIFE MEMBERSHIP TO WILLIAM DAVID REEVE*

FRANKLIN FREY
Cass Technical High School, Detroit, Michigan

The Board of Directors at its meeting on May 11, 1946 at Detroit, Michigan, established a type of membership to be known as an EMERITUS LIFE MEMBERSHIP. This Emeritus status, which is granted in recognition of long and continuous membership in the Central Association of Science and Mathematics Teachers includes voting privileges, convention attendance, and subscription to our journal, SCHOOL SCIENCE AND MATHEMATICS. The Emeritus membership will continue in effect for the life of the recipient and at no cost. In other words, Emeritus status is in all respects the same as regular membership except that it is honorary and the member ceases to pay dues. To be eligible a member must meet the following qualifications:

1. He must have been a member of the association for twenty-five consecutive years, and
2. He must have retired from active teaching.

President Meyer asked me to ascertain from the business manager the names of any of our membership who might qualify under the conditions given. Some correspondence was necessary to check for eligibility and to secure information relating to the citation accompanying such an award.

We come now to present an *Emeritus Life Membership* in the *Central Association of Science and Mathematics Teachers*, in absentia, to *William David Reeve*.

I am sure that the many friends of Dr. Reeve will join me in extreme regret that circumstances are such that it is impossible for Dr. Reeve to be here in person. We could shower him with our cordial congratulations for this honor as we would meet him in the corridors of the convention. However, it is still possible for us to give such congratulations and couple with them our earnest hope for his speedy recovery through the medium of the mail. I am sure that many of you will do so. I will quote from Dr. Reeve's letters in order that you may know he regrets his inability to be here:

"Nothing would please me better than to attend the November meeting this year, but I am not going to be able to make it as I have not fully recovered from a back injury which I have been fighting for two years. I hope that later I may be able to see you all. In any event I want to express to you and to the Association my very great ap-

* Presentation made at the Annual Meeting of the Central Association of Science and Mathematics Teachers at Chicago, November 24, 1950.

preciation for the honor of Emeritus Life Membership which you plan to bestow upon me and I shall look forward to receiving it with great anticipation."

WILLIAM DAVID REEVE you have moved from the teaching of mathematics in Indiana to the University of Chicago High School. While there you took an active part in the organization of the Men's Mathematics Club of Chicago in 1913. Your next move took you to the University of Minnesota High School as Head of the Mathematics Department and later as Principal. While at Minnesota your great interest in the professional growth of teachers of mathematics led you to actively participate in the founding of the National Council of Teachers of Mathematics in 1921. In 1923 your area of usefulness was further widened by moving to the position of Head of Department of the Teaching of Mathematics at Teachers' College, Columbia University. For a quarter of a century you have in this strategic location influenced directly some 4,000 teachers of mathematics from all sections of the country. However, your influence was not limited to the campus, but has extended to the whole country through *The Mathematics Teacher* which you have edited since 1926, through the 19 yearbooks of the National Council issued under your direction, through the more than twenty books authored or co-authored by you, and through the numerous articles, editorials, and short statements which have flowed from your experience to enrich the whole field of mathematics teaching.

Through all these years, while your interests have broadened to the whole country, you have maintained your membership in the Central Association of Science and Mathematics Teachers. Now that you have retired from active teaching and are thus eligible for Emeritus Life Membership in this Association, I have caused to be prepared this certificate by which all the privileges of such membership are bestowed upon you.

OLD PROBLEMS STATED ANEW[1]

JULIUS SUMNER MILLER
Dillard University, New Orleans 22, Louisiana

1. Why does a brook gurgle? Is the pitch of this purling altered by a change of temperature?

2. If one *opens* his mouth and exhales (blows out) forcefully the air that emerges is *warm.* Why does pursing the lips and blowing give a *cold stream of air?* Classically, how can one blow hot and cold?

3. Why, when a liquid rotates with uniform angular velocity about a vertical axis, is the free surface a paraboloid of revolution?

[1] Julius Sumner Miller, *Am. J. Physics*, 18, 534 (1950).

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Missouri

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve his readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

Late Solutions

2218. *J. H. Means, Austin, Texas; Donald Roe, Sault Ste. Marie, Michigan.*

2219. *F. A. Lee, Williamsburg, Virginia.*

2121. *Proposed by Julius S. Miller, New Orleans.*

Deduce two trigonometric identities from the algebraic identity by making some appropriate substitution:

$$1+x+x^2+x^3+\cdots+x^{n-1}=\frac{1-x^n}{1-x}.$$

Solution by V. C. Bailey, Evansville, Indiana

If we substitute $\cos\theta+i\cdot\sin\theta$ for x in the identity

$$1+x+x^2+x^3+\cdots+x^{n-1}=\frac{1-x^n}{1-x}$$

and equate the real and imaginary parts respectively, and simplify, the following trigonometric identities result:

$$1+\cos\theta+\cos 2\theta+\cdots+\cos(n-1)\theta=\frac{(\cos n\theta-1)(\cos\theta-1)+\sin n\theta\sin\theta}{(\cos\theta-1)^2+\sin^2\theta}$$

$$\sin\theta+\sin 2\theta+\cdots+\sin(n-1)\theta=\frac{\sin n\theta(\cos\theta-1)-\sin\theta(\cos n\theta-1)}{(\cos\theta-1)^2+\sin^2\theta}.$$

Note: this problem is solved in Weisner's *Theory of Equations.*

In a solution by C. W. Trigg, with the identity cleared of fractions, he substituted $x=\cos^2 A$ and obtained the identity: $\sin^2 A(1+\cos^2 A+\cos^4/p+\cdots+\cos^{2n-2} A)=1-\cos^{2n} A$. Also by substitution of $x=\sin^2 A$, he obtained a similar identity except the sin A and cos A are replaced by cos A and sin A respectively.

2222. *Proposed by Norman Anning, University of Michigan.*

What points are common to all circles, $(x-a)(x-b)+y(y-c-a)=0$, where the number a is a parameter?

Solution by C. W. Trigg, Los Angeles City College

It is evident upon inspection that $(b, 0)$ falls on all the circles. Let $y=mx+k$ pass through $(b, 0)$, then $y=m(x-b)$. The abscissas of the intersections of this line with the circles will be the roots of

$$(x-a)(x-b)+m(x-b)[m(x-b)-c-a]=0, \quad \text{or}$$
$$(x-b)[(m^2+1)x-m^2b-mc-a(m+1)]=0.$$

If the intersections are to be common to all members of the family, their coordinates must be independent of a, hence $m=-1$, so $x=b$ and $(b-c)/2$ and the corresponding values of y are 0 and $(b+c)/2$. That is, in general, all members of the family of circles have two points in common, $(b, 0)$ and $[(b-c)/2, (b+c)/2]$. If $c=-b$, then there is but one point in common, $(b, 0)$, at which all members of the family are tangent.

A solution was also offered by V. C. Bailey, Evansville, Ind.

2223. *Proposed by Norman Anning, University of Michigan.*

In a plane quadrilateral $ABCD$, with AC and $\perp BC$, if squares are constructed on AB and CD as diagonals the squares have a vertex in common. Also squares on AD and BC as diagonals have a common vertex.

Solution by C. W. Trigg, Los Angeles City College

Since ABC is an isosceles right triangle, obviously C is a vertex of the square constructed on AB as a diagonal. C must also be the vertex of the square constructed on CD as a diagonal.

To disprove the second statement in the proposal, we chose a contra-example. Let AD be $\perp AC$ and lie on the opposite side of AC from BC. Then squares constructed on AD and BC as diagonals will be wholly on opposite sides of AC except for the vertices A and C, which being distinct points cannot constitute a common vertex. In fact, the only cases in which these squares can have a common vertex are:

1. The five degenerate quadrilaterals in which
   a) $D \equiv C$,
   b) $D \equiv B$,
   c) ACD is a straight line with $AD=2\,AC$,
   d) BCD is a straight line with $BC=CD$,
   e) CBD is a straight line with $CD=2CB$.
2. The two crossed quadrilaterals in which $AD \perp AC$, D and B lie on the same side of AC, and
   f) $AD=BC$,
   g) $AD=2BC$.
3. The concave quadrilateral in which B and C are on opposite sides of AC, $AD=BC\sqrt{5}$ and angle $CAD=\pi/4-\arccos(3/\sqrt{10})$.

2225. *Proposed by Roy Wild, Moscow, Idaho.*

Find a triangle in which the altitudes and the three sides are consecutive integers. (From Dickson's "History of the Theory of Numbers.")

Solution by C. W. Trigg, Los Angeles City College

The area of a triangle is $\frac{1}{2}ah_a=\frac{1}{2}bh_b=\frac{1}{2}ch_c$. So, if $a<b<c$, then $h_a>h_b>h_c$. Now every altitude is less than the two sides issuing from the same vertex, so the only two possible orders of magnitude of the sides and altitudes are

$$h_c<h_b<a<h_a<b<c \text{ and } h_c<h_b<h_a<h<b<c.$$

Now if $h_a=a+1$, $b=a+2$, and $c=a+3$, then $s=(3a+5)/2$ and by Heron's formula, we have

$$\tfrac{1}{2}a(a+1)=\tfrac{1}{4}\sqrt{(3a+5)(a+5)(a+1)(a-1)}, \quad \text{or}$$

$(a+1)(a^3-13a^2-5a+25)=0$. This equation has no positive integral root.

If some h and the sides are consecutive integers, $h+1$, $h+2$, $h+3$, the semi-perimeter is $(3h+6)/2$. Then by Heron's formula.

$$\tfrac{1}{2}h(h+k)=\tfrac{1}{4}\sqrt{(3h+6)(h+4)(h+2)h}, \quad \text{or}$$
$$h[h^3+8(k-3)h^2+4(k^2-15)h-48]=0.$$

If $k=1$, $h^3-16h^2-56h-48=0$, which has no positive integral root. If $k=3$, $h^3-24h-48=0$, which has no positive integral root. If $k=2$, $(h+2)(h+2)(h-12)=0$. Hence $h_b=12$, $a=13$, $b=14$, $c=15$, $h_a=168/13$, $h_c=56/5$. Since this is the only solution in which *an* altitude and the three sides are consecutive integers, it follows that there is no Heronian triangle in which the *three* altitudes and the three sides are consecutive integers.

Presumably the reference is to L. E. Dickson, *History of the Theory of Numbers*, Stechert (1934), Vol. II, p. 198, where it is stated "W. A. Whitworth noted that the triangle with the altitude 12 and sides 13, 14, 15 is the only one in which the altitude and sides are consecutive integers. (Math. Quest. Educ. Times, 36, 1881, 42)."

Editor's note: The problem should have been stated, "Find a triangle in which one of the altitudes and the sides are consecutive integers in some order."

2226. *Proposed by B. S. Libby, San Francisco, Calif.*

Construct a triangle given two sides and its area.

Solution by Margaret Joseph, Milwaukee, Wisconsin

Let a and b be the two sides with C the included angle. If the area is A, then $A=\frac{1}{2}ab \sin C$.

From this formula sin C can be found and hence angle C can be constructed. The triangle is unique and it can easily be constructed.

Solutions were also offered by C. W. Trigg; David Rappaport, Chicago and the proposer.

Editor's comment on this issue: The late publication of the December magazine, and the holiday period may be the cause of so few contributors to the issue. When any month's issue is published a contributor has until about the first of next month to offer solutions. After that they are recorded as "late" in next issue. For example the solution for the January magazine should reach the editor by Feb. 1. Hurry!!

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each high school contributor will receive a copy of the magazine in which the student's name appears.

For this issue the Honor Roll appears below.

2215, 2216, 2217, 2218, 2219. *W. G. Deeks; P. L. deRuiter; W. M. H. Grover; C. I. Mason; A. C. Pathy; B. G. Raymond; R. L. W. Till; and G. F. West of Upper Canada College in Toronto.*

2216. *John Hutchins, Lowell High School, San Francisco, Calif.*

2218. *Jerry Kerrish, Leo High School, Chicago, Ill.*

PROBLEMS FOR SOLUTION

2239. *Proposed by Julius S. Milleo, New Orleans, La.*

State in mathematical notation or symbols any ideas, concepts, theorems, equalities, etc. which impress you as being eminently beautiful and embracing. For example, the nine point circle: also $e^{\pi i}+1=0$.

Editor's note: Send them in. It should prove interesting.

2240. *Proposed by Cecil B. Read, Wichita, Kansas.*

Show that in an evening of bridge, the chance that any given player will have a hand void of some suit at least twice is better than one in three, assuming that 25 deals are made during the evening.

2241. *Proposed by Julius S. Miller, New Orleans.*

Form the cubic equation whose roots are x_1, x_2, x_3, where

$$x_1=-\sqrt[3]{\frac{7}{2}+\frac{7}{18}\sqrt{-3}}-\sqrt[3]{\frac{7}{2}-\frac{7}{18}\sqrt{-3}}$$ Call the first term A, second B.

$$x_2=-\omega A-\omega^2 B.$$

$$x_3=-\omega^2 A-\omega B.$$

2242. *Proposed by Dwight L. Foster, Florida A and M College.*

If p, q, r be the bisectors of angles A, B, C, respectively, of triangle ABC, prove that

$$\frac{\cos A/2}{p}+\frac{\cos B/2}{q}+\frac{\cos C/2}{r}=\frac{1}{a}+\frac{1}{b}+\frac{1}{c}.$$

2243. *Proposed by Dwight L. Foster, Florida A and M College.*

Derive the value of the integral (do not use methods given in calculus)

$$\int \sec\theta d\theta.$$

2244. *Proposed by William R. Ware, Canby, Oregon.*

In terms of base radius, find the volume common to three intersecting right circular cylinders, having the same radii whose axes are mutually perpendicular at the point of intersection.

SECTION REPORTS OF CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS

Biology Section

Donald B. O'Brien opened the Biology section meeting of the Central Association of Science and Mathematics Teachers at the Edgewater Beach Hotel, Chicago, Illinois. Vice-Chairman Frances M. Gourly and Secretary Ruby E. Fremont were introduced.

Dr. Francis D. Curtis, Professor of Education and the Teaching of Science, University of Michigan and Head of the Department of Science, University of Michigan High School, and Dr. James A. Reyniers, Director of the Laboratories of Bacteriology, University of Notre Dame, presented a very interesting program on "Some Practical Suggestions for the Teaching of High School Biology," and "Basic Research in Science and the Student."

The meeting closed with the following report of the nominating committee:

Chairman—Frances M. Gourly, La Porte Senior High School, La Porte, Indiana.

Vice-Chairman—Ruby E. Fremont, Calumet High School, Chicago, Illinois.

Secretary—Nelson Lowry, Arlington Heights, Illinois.

RUBY E. FREMONT, *Secretary*

GENERAL SCIENCE SECTION

The annual meeting of the General Science Section was opened by Mr. Russell Shedd, chairman, He introduced Sister Mary Ellen O'Hanlon of Rosary College, River Forest, Illinois, and Dr. Francis D. Curtis of the University of Michigan.

Sister Mary Ellen spoke on the topic "The Natural Sciences at the Junior High School Level." She suggested that serious consideration be given to the fundamentals of education if deficiencies are found in the science classes. In discussing the various methods of science teaching, she also mentioned the use of audio and audio-visual aids to teaching and the proper use of demonstrations and experiments. Likewise the speaker appealed to teachers to give attention to the senses, memory, imagination, and higher faculties in reaching the children. Tests and examinations were singled out for their contributions to teaching as well as evaluations in junior high school science.

The subject of Dr. Curtis' talk was "The Teaching of General Science from the Teacher's Standpoint." In his presentation he stated seven theses related to problems and techniques in the teaching of General Science. He pointed out that this subject has achieved a rightful place in the school curriculum but can be taught much more effectively than it presently is. Other pertinent points emphasized the undesirability of the integration of general science with mathematics, the inadvisability of an advanced general science course, and prospects for a bright future for the subject.

The officers elected for next year are Fred W. Fox, McGuffey High School, Oxford, Ohio, chairman; Bert E. Grove, Lake Forest Academy, Lake Forest, Illinois, vice-chairman; and Sister Mary Ellen O'Hanlon, Rosary College, River Forest, Illinois, secretary.

FRED W. FOX, *Acting Secretary*

GEOGRAPHY SECTION

The Geography Section was host to the National Council of Geography Teachers for its annual meeting.

The afternoon session presented four speakers. The first, Dr. Otis P. Freeman, discussed geography in its interrelationship with the other fields of science. He explained the points of contact between geography and such fields as aviation, weather, engineering, biology, forestry, astronomy, mathematics, conservation and public planning, and military tactics. He made the concluding statement that geography is dynamic, not a static subject and that geography, properly taught, can coordinate other sciences.

Dr. Clarence Vinge discussed the Mercator projection. He mentioned the map as the most useful of geographical tools, and the map grid as the most important factor of map projections. The Mercator map is most useful to navigators, and is coming to be used by aviators because in this projection the rhumb line is a straight line. The major error of the Mercator projection is the incorrect size of the land areas in high altitudes.

The third speaker was Dr. Edward W. B. Espenshade. He spoke on the topic, "The teaching of mathematical concepts in geography." The difficult problem facing the teacher is to represent the earth on a scale suitable for classroom use. The scale of the map is the degree of this reduction in size. The teacher should help the student visualize the scale.

The last speaker was Dr. James K. Anthony who spoke on "Place of astronomy in a geography curriculum." He mentioned the following topics from astronomy as important in the study of geography; the rotation of the earth on its axis,

the Milky Way Galaxy, the revolution around the sun, the rise and fall of the tides, astronomical photography, concept of interstellar matter.

The Geography Section shared the general meeting, luncheon, and banquet with the National Council of Geography Teachers. We appreciated the presence and inspiration of the leaders in the field of educational geography.

FLOY HURLBUT, *Acting Secretary*

BOOKS AND PAMPHLETS RECEIVED

INTRODUCTORY NUCLEAR PHYSICS, by David Halliday, *University of Pittsburgh, Pittsburgh, Pennsylvania.* Cloth. Pages ix+558. 13.5×21.5 cm. 1950. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Price $6.50.

FIRST CHEMISTRY BOOK FOR BOYS AND GIRLS, by Alfred Morgan. Cloth. 179 pages. 13.5×21 cm. 1950. Charles Scribner's Sons, 597 Fifth Avenue, New York, N. Y. Price $2.75.

FARMER IN THE SKY, by Robert A. Heinlein, *Author of Rocket Ship, Galileo, Red Planet, etc.* Cloth. 216 pages. 13.5×20.5 cm. 1950. Charles Scribner's Sons, 597 Fifth Avenue, New York, N. Y. Price $2.50.

SOURCEBOOK ON ATOMIC ENERGY, by Samuel Glasstone, *Consultant to the United States Atomic Energy Commission.* Cloth. 546 pages. 15×23 cm. 1950. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York 3, N. Y.—Price $2.90.

OUR DESERT NEIGHBORS, by Edmund C. Jaeger. Cloth. Pages x+239. 13.5 ×21 cm. 1950. Stanford University Press, Stanford, Calif. Price $5.00.

ELEMENTARY THEORY OF EQUATIONS, by Samuel Borofsky *Brooklyn College.* Cloth. Pages x+302. 13.5×21 cm. 1950. The Macmillan Company, 60 Fifth Avenue, New York 11, N. Y. Price $4.25.

THE HEBREW IMPACT ON WESTERN CIVILIZATION, Edited by Dagobert D. Runes, *Doctor of Philosophy of the University of Vienna.* Cloth. Pages xiv+922. 13×21.5 cm. 1951. The Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $10.

A WATER POLICY FOR THE AMERICAN PEOPLE. The Report of the President's Water Resources Policy Commission, Morris L. Cooke, *Chairman.* Paper. 445 pages. 20×26 cm. 1950. For sale by the Superintendent of Documents, Government Printing Office, Washington 25, D. C.

APPLIED NUCLEAR PHYSICS, SECOND EDITION, by Ernest C. Pollard, *Professor of Physics, Yale University,* and William L. Davidson. *Director of Physical Research, The B. F. Goodrich Company.* Cloth. Pages ix+352. 14.5×23 cm. 1951. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Price $5.00.

ALGEBRA, ITS BIG IDEAS AND BASIC SKILLS, by Daymond J. Aiken, *Head of Mathematics Department, Lockport Township High School, Lockport, Illinois,* and Kenneth B. Henderson, *Association Professor of Mathematics Education, University of Illinois.* Cloth. Pages xv+409. 15×23.5 cm. 1950. Harper and Brothers, 49 East 33rd Street, New York 16, N. Y. Price $2.48.

LIFE INSURANCE MATHEMATICS, by Robert E. Larson, *Fellow of the Society of Actuaries, Lecturer, School of Commerce,* and Erwin A. Gaumnitz, *Professor and Assistant Dean, School of Commerce, both in the University of Wisconsin.* Cloth. Pages vii+184. 14.5×23 cm. 1951. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Price $3.75.

THE ATOM AT WORK, by Jacob Sacks, Ph.D., M.D., *Brookhaven National Laboratory, Long Island, N. Y.* Cloth. Pages xii+327. 14.5×23 cm. 1951. The Ronald Press Company, 15 East 26th Street, New York 10, N. Y. Price $4.00.

BASIC ARITHMETIC, BOOK ONE, by Editor-in-Chief, I. I. Nelson, Ph.D., *Professor of Education, University of Texas.* Cloth. Pages xv+385. 12.5×18.5 cm. 1950. Noble and Noble, Publishers, Inc., 67 Irving Place, New York 3, N. Y. Price, Pupils Edition (without answers) $1.75, with answers $2.00.

BASIC ARITHMETIC, BOOK TWO, by Editor-in-Chief, I. I. Nelson, Ph.D., *Professor of Education, University of Texas.* Cloth. Pages xviii+386. 12.5×18.5 cm. 1950. Noble and Noble, Publishers, Inc., 67 Irving Place, New York 3, N. Y. Price, Pupils Edition (without answers) $1.75, with answers $2.00.

BETTER LIVING THROUGH WISE USE OF RESOURCES, by Halene Hatcher, *Educationist (Geography and Conservation), Division of Elementary and Secondary Schools.* Bulletin 1950, No. 15. Pages iv+W6. 15×23.5 cm. Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 25 cents.

PRACTICAL NURSING CURRICULUM. Suggestions for Developing a Program of Instruction Based upon the Analysis of the Practical Nurse Occupation (Misc. No. 8, 1947). Misc. No. 11. Paper. Pages vi+140. 22.5×29 cm. Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 65 cents.

CHANGING CONCEPTIONS IN GENERAL SCIENCE TEXTBOOKS, by Maitland P. Simmons, *Irvington High School, Irvington 12, New Jersey.* Paper. 12 pages. (3 Reprints from *The Journal of Experimental Education*). Price 50 cents.

PROBLEM OF THE WEEK, by Mel Lieberstein, *Collinsville Township High School, Collinsville, Illinois.* A list of Problems to be Posted for Solution. Solutions are given on the following sheet. 22×36 cm. 1951. Price $2.50 each, $6.50 for three.

BOOK REVIEWS

FARMER IN THE SKY, by Robert A. Heinlein, *Author of Rocket Ship, Galileo, Red Planet, etc.* Cloth. 216 pages. 13.5×20.5 cm. 1950. Charles Scribner's Sons, 597 Fifth Avenue, New York, N. Y. Price $2.50.

This is really a story for those who love fiction. The author, following *Space Cadet* and *Red Planet*, again shows that he can really use his imagination. About the only parts that are factual are the positions of the planets and their satellites and their distances from the Earth and the Sun. It is the story of a family, living in California sometime in the future, probably about 2000 A.D., who because of crowded conditions on Earth decided to migrate to Ganymede, the largest of Jupiter's moons. The young man of the family, just about ready to enter college, is the Boy Scout hero, who has a remarkable trip in a great space ship. One incident gave Bill his chance. A meteor tore a hole in the floor right at his feet. This he blocked by stuffing his boy scout uniform into the hole. We are not told how the other holes it made were closed; it must have made only one, at a very convenient place for repair.

Bill and the family reach Ganymede, take up a section of land, and Bill becomes a gardener. No tools are available for real farming. After getting a good start a terrible *earth* quake tore up the farm buildings, froze nearly everything alive, including about two-thirds of the people, but Bill and the family came through. It was the life of a pioneer, Ganymede style, and Bill decided it was the life for him.

G. W. W.

OUR DESERT NEIGHBORS, by Edmund C. Jaeger. Cloth. Pages x+239. 13.5×21 cm. 1950. Stanford University Press. Stanford, Calif. Price $5.00.

This is the book for all visitors to our American Deserts. It tells how to find the many interesting animal inhabitants, how they live, what they eat, how they build their nests or dens. To gain all the information the author must have spent years roaming over the great dry wastes and he must have devoured all previously written books and articles on the subject. He gives us the information he has collected, not in words as dry as the desert sands, but as true stories of the living animal inhabitants of the country of the yuccas, the chollas, the pinyons, and the Joshua trees. Seventeen short stories tell of the gray fox, the desert coyote, the bighorn sheep, the pack-rat, the spotted skunk, and a host of other animals. These are followed by sixteen on the feathered desert inhabitants—the sparrow, the falcon, the cactus wren, the road runner, desert humming birds—to name only a few. A few pages are used to tell of the scorpions, the millipeds, and spiders, a few pages more on the desert snakes, and finally the interesting life and habits of the tortoise. It is a book for young and old, nicely illustrated with photographs and drawings; excellent as a gift for anyone interested in life in the desert.

G. W. W.

POCKET ENCYCLOPEDIA OF ATOMIC ENERGY, Edited by Frank Gaynor. Cloth. 204 pages. 13.5×21.5 cm. 1950. Philosophical Library, 15 East 40th Street, New York 16, N. Y. Price $7.50.

This is a book made up for the purpose of helping the student and the teacher of nuclear physics to obtain a clear view of his subject without wasting time hunting for definitions of terms and concepts that are scattered through endless volumes of scientific journals. The book discusses some two thousand or more words and phrases used continually in texts, lectures, and scientific reports. Many charts, tables, and diagrams are given and explained. Brief sketches are given of the leading scientists who have developed atomic and nuclear science. Some of the discussions are too brief to be of much value to the beginner, as "diffraction. The effect exerted on waves by an obstacle introduced in their path." But often a word is given a half page or more as "beta particle" and "gamma ray." An isotope table covers twenty-one pages. It is a small book at a rather high price, but it is worth the money for anyone starting work or reading in the subject.

G. W. W.

SOME THEORY OF SAMPLING, by William Edwards Deming, *Adviser in Sampling, Bureau of the Budget, Washington*, also *Adjunct Professor of Statistics, Graduate School of Business Administration, New York University*. Cloth. Pages xvii+602. 14.5×23 cm. 1950. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Price $9.00.

This book purports to present modern sampling theory, not from the point of view of the mathematical statistician, but rather for those who, with some background in elementary statistics, wish to learn more about the theory and practice of sampling. The book would seem to admirably accomplish what the author has set as an objective. The development steers a careful middle course. On the one hand there is not encountered the feeling that the author is proud of the fact that he never had any formal training in mathematics; on the other hand, the reader without advanced mathematical training is not discouraged by finding the treatment completely beyond his grasp. It is suggested in the preface that the first thirteen chapters might constitute a year course for students in the social sciences and commerce, and that except for occasional uses of forgotten calculus, the material does not go beyond the level of college algebra. The statement is indeed true, but no doubt several readers will also need to refresh their algebra.

In the opinion of the reviewer, the first two chapters involving no mathematics (not even algebra), which deal with the planning of surveys and the vari-

ous errors of a survey, constitute one of the most readable, informative, and complete treatments of the subject that he has ever encountered. The discussion may at times seem a little lengthy, but one soon realizes that extensive discussion is essential if the author is to cover the majority of the possible contingencies.

Throughout the text are found exercises which illustrate many of the principles presented. In many cases a solution is presented, in others this is left to the student. An unusual feature of the book is the inclusion, both in connection with discussion of theory and with the solution of problems, of "remarks" which are very valuable in clarifying the concepts.

Although it is doubtful that the author would claim as a primary objective the treatment of the subject of statistical quality control, the fact remains that the discussion is more complete and adequate than found in some texts on this topic.

Many of the illustrative examples are taken, as might be expected, from problems arising in the Bureau of the Census, a chapter of some 25 pages discusses applications of the theory to a population sample taken in Greece in 1946. Although a some points the discussion may seem to be longer than necessary, it is certainly better to err in this direction than in the direction of too extensive condensation.

The book would seem to have very definite value for several purposes: as a textbook (equally valuable in the fields of social science and of engineering and of business); as a guide for the theoretical statistician who suddenly finds himself confronted with some practical problem; as a source of information for the research worker in some field who needs to use sampling methods yet has had no formal training in statistics; and last, but by no means least, as a reference work for the college or technical library. In each case the book is a distinct addition to any available literature. The mathematical treatment in the last 200 pages requires a knowledge of calculus, but is presented in such a manner that this book will be found of great value as an introduction to or as supplementary material to accompany one of the standard books in mathematical statistics. If for no other reason, the detail with which solutions and mathematical developments are presented, with occasional explanatory notes, will make the book of great value to the reader whose mathematical background is either weak or "rusty."

CECIL B. READ
University of Wichita

FIRST COURSE IN PROBABILITY AND STATISTICS, by J. Neyman, *The University of California, Berkeley*. Cloth. Pages ix+350. 16×23.5 cm. 1950. Henry Holt and Company, New York. Price $3.50.

This book is planned for a one semester first course in mathematical statistics, assuming a background limited to high school algebra. Certain starred sections presume either additional background or greater maturity. Even with the omission of these sections, granted that the treatment is considerably more elementary than that found in other recently published texts, there are points at which additional mathematical background will have to be supplied in some manner (to mention only two places: the use of such functions as arcsec x and e^{-x} on page 166; the concept of slope of a curve on page 231). In general, however, the presentation has been such as to allow the reader to follow the text without extensive mathematical background. For such a reader, the greatest difficulty may be that the mere appearance of portions of the book, involving hitherto unencountered symbolism, may discourage him at the outset. He will fail to realize how the material has been simplified, for example, by such restrictions as omission of consideration of probability problems involving an infinite set of elements.

The use of the term "hypothesis tested" rather than the more commonly encountered "null hypothesis" seems a definite improvement. One questions, however, the gain by using both the term "arrangement" and the term "permutation"; students in their previous work in algebra are likely to have found no different name used for the permutations of n objects n at a time and the permutations of n objects k at a time.

There are many illustrative problems and exercises; answers or partial answers are given somewhat less than half the time. A chapter of over sixty pages discusses applications of probability to genetics. The index is not always complete. The text is undoubtedly one of the best available on the elementary level; whether it can be used in freshman or sophomore courses is somewhat debatable —depending of course on the particular school.

CECIL B. READ

HIGHLIGHTS OF THE NINTH ANNUAL MATHEMATICS INSTITUTE—MATHEMATICS AT WORK. Duke University, Durham, North Carolina. August 8–19, 1949. Paper. Pp. 127. 21.5×28 cm.

This is a report of lectures, discussions, and study group activities at the 1949 Institute held in the summer. The material is treated under several major headings: *Horizons* covers such general lectures as "The Spirit of Mathematics" or "Famous Problems and Ideas"; *Application of mathematics; Pure mathematics*, two papers, one on non-Euclidean geometry aad the other on number theory; *Teaching of mathematics; Study groups.*

The material, as might be expected, varies considerably in the level of difficulty. As a whole, it seems to be a very fruitful source of aid to the teacher, particularly at the secondary school or junior college level. There are several short bibliographies, and one rather extensive bibliography accompanying the study group section. Unfortunately these are not annotated, hence there is no method of determining their value to the teacher. There is no index.

CECIL B. READ

PROBABILITY AND THE WEIGHING OF EVIDENCE, by I. J. Good, M.A., Ph.D., *Former Lecturer in the Mathematics at the University of Manchester, England.* Cloth vii+119. 15.5 by 22.5 cm. 1950. Hafner Publishing Company, 31 E. 10th Street, New York 3, N. Y. Price $3.00.

This book attempts to provide a mathematical theory of probability adequate for the purpose suggested in the title. The text starts with an analysis of existing theories of probability. After discussing their origin, six formal axioms are stated from which a fairly detailed theory is developed. The application of the theory is discussed in some detail with emphasis on the "degree of belief." In a rather interesting manner the author has adopted the engineer's concept of decibels, and applies it to the concept of weight of evidence.

A moderate degree of mathematical maturity is needed to read the text. Probably advanced calculus and point set theory should be at the command of the reader.

Whether or not one agrees with this particular theory, it must be admitted that the treatment is sound and worthy of consideration.

CECIL B. READ

MATHEMATICAL SNAPSHOTS, by Hugo Steinhaus, *Professor of the Calculus of Probability and Mathematical Statistics in the University and Polytechnicum in Wroclaw, Poland.* Cloth. Pages vi+266. 13.5 by 21.5 cm. 1950. Oxford University Press, 114 Fifth Avenue, New York 11, N. Y. Price $4.50.

This is a reprint with revisions and extensions of a book which has been out of print for several years. The book is indeed a gold mine of supplementary material, varying from simple problems and tricks to discussions of some relatively advanced topics. Most of the material requires only elementary algebra as a background. As a result there is a great deal of material which would be of value for high school mathematics club programs. Some more advanced topics could be used in similar manner on the college level.

There are, for example, some interesting variations of the common "naughts and crosses game." A discussion of the "fifteen puzzle" is of interest, although the reader may not agree that the puzzle is no longer in fashion. The discussion of

the distribution of an inheritance will be intriguing. Those interested in solid geometry model construction will find some unusual suggestions.

A series of notes gives reference to many suggestions for further reading. The book unfortunately does not have an index. This book would be found extremely valuable for any high school or college library, to say nothing of the teacher's private library.

CECIL B. READ

MEASUREMENT AND DIMENSIONALITY, by Aaron Bakst, *School of Education, New York University*. Paper (unbound). Pp. 70. 21.5×28 cm. 1950. New York University Bookstore.

In a foreword the author points out that the literature on measurement and dimensionality is very limited, and in general beyond the level of training of the average teacher. This material is an attempt to fill the gap in the professional literature; moreover, he hopes to interest elementary teachers in the topic. In the opinion of the reviewer, it is extremely doubtful if more than a very small percentage of elementary teachers will, even if they obtain this monograph, even begin to follow the material. In some cases they will feel the treatment too advanced, in others it will merely be a lack of interest.

The scope of topics presented is rather broad. There is treatment, in more or less detail, of such topics as dimensional analysis, Hilbert's set of postulates for geometry, a discussion of the Dedekind cut. In some cases the treatment seems very good, in other cases it has not been too successful. For example, the reviewer did not feel that the author had been too successful in clarifying the distinction between quantity and magnitude, hence a colleague was asked to read this section. Although neither felt he could improve on the material, both were in agreement that the presentation was far from clear.

The material, apparently reproduced by mimeograph, contains an unreasonably large number of typographical errors. For example, on page 2, there are four typographical errors in five consecutive lines. There is a twelve item bibliography, a table of contents, but no index. Unless the teacher has a special interest in this field, it is doubtful, particularly in view of the non-permanent form in which the material is put up, whether the monograph has any particular value as an addition to the professional library of the instructor.

CECIL B. READ

MID-CENTURY. SOCIAL IMPLICATIONS OF SCIENTIFIC PROGRESS, by John Ely Burchard, *Editor, Dean of Humanities, M.I.T.* Cloth. Pages xx+549. 16×24 cm. 1950. John Wiley & Sons, New York City. Price $7.50.

This is the record of an international Convocation, held the spring of 1949 at Cambridge, Mass., to explore some of the problems that have been raised by science for the twentieth century.

Some forty leading scholars and men of affairs met to exchange views and this well edited report offers an able and illuminating statement of the varied points of view of these great minds with respect to man and his relation to the world in which he lives. Among the problems here presented are: exploitation and conservation of natural resources; technological assistance to undeveloped areas; the influence of science on man's faith; the role of the individual in modern society; specialized education for the world of tomorrow and the support of higher education in the future.

The Convocation was organized upon the basis of general presentations by outstanding speakers such as: Retiring-president Karl T. Compton, of M.I.T.; Winston Churchill; Harold Stassen; President-elect James R. Killian of M.I.T.; and the editor of the report, Dean of Humanities (M.I.T.) John Ely Burchard. Six panels, using a score or more participants, gave varied points of view to such topics as: Men against Nature; Men against Men; Science and the Human Spirit; The Individual in a World of Institutions; Specialization in Education and the State, Industry and the University.

An unusually thorough job of editing and integrating of the materials, relayed in this publication, is evident to the reader. Not only are the papers in complete form but informal discussion, as recorded on tape, is here transcribed into print. The editor has provided a very full documentation from other speakers and writers and has given a generous offering in footnotes which interrelate the thoughts which repeated themselves in the course of the discussions.

The style and organization of the material leads to a lively interest upon the part of the reader. One is impelled to remark, even before a complete scanning of the 600 pages, that here is a volume that might, with reason, be considered required reading for all teachers of science who desire that their instruction be oriented against a background of world need.

The volume is well indexed and cross-referenced and there are twelve appendices of materials of pertinence to topics treated but too lengthy for inclusion as footnotes.

B. CLIFFORD HENDRICKS
University of Nebraska, Lincoln

CONSERVATION OF NATURAL RESOURCES, edited by Guy-Harold Smith, *Chairman, Department of Geography, Ohio State University*. Cloth. Pages xii+552. 18×24 cm. John Wiley & Sons, Inc., New York. Price $6.00.

The unwise use of nearly all our natural resources makes the incorporation of conservation courses in our school curricula at all levels imperative. Conservation is no longer a matter of dollars and cents saving for an enterprising country; it is a matter of national survival.

Conservation of Natural Resources consists of contributions from twenty men, each of whom is a specialist in some phase of conservation. First there is a general review of the conservation problem in this country, and then each author utilizes a chapter in describing the facts concerning the use and management of his particular resource specialty.

There is a definite value in combining the specialized talents of twenty authorities in one such book. It can be valuable in teaching conservation courses either in high school or college courses. But, in my opinion, it can be used best only as a reading reference. There is definite continuity in the conservation picture, for all our natural resources are interrelated. This book loses that continuity. Students are likely to see each issue as separate and disconnected from the whole unless they are carefully guided. With evangelic teaching to overcome the diversity of language and statements, this book could be a valuable teaching aid. And it is certainly an excellent reference book.

GEORGE S. FICHTER
Miami University, Oxford, Ohio

MATHEMATICS OF RELATIVITY, by G. Y. Rainich, *Professor of Mathematic at the University of Michigan*. 167 pages. Wiley, 1950. $3.50.

This book, although contributing nothing new to the subject, presents the material in a very excellent pedagogical fashion. Much of the contents (indeed, most of it) has appeared before in texts and periodicals, but not before in as well-woven a form for teaching. As the author puts it: "In keeping with the purpose of the book, which is to give a consistent and clear presentation of the theory of relativity in as simple a form as is consistent with the clarity of the fundamental concepts, no attempt is made to cover the literature with any degree of completeness."

The title of the book reflects the author's point of view. Only the mathematical aspect of the subject is treated. The problem of the physics, or, if you please, physical reality, is not touched.

This text is the outcome largely of a course on the mathematics of relativity which the author has been giving at Michigan for more than 20 years. Its instructional soundness is therefore established. The order, from simple to complex, without loss of rigor, is elegantly teachable.

One extension of the subject deserves particular mention. Originally general relativity theory as proposed by Einstein failed to account for electromagnetic phenomena "although it takes care of phenomena interpreted earlier in terms of of gravitational forces." A number of generalizations of curved space have been proposed as the basis of a theory which would accommodate electromagnetism as well as gravitation. In Section 19 the author shows that gravitation together with electromagnetism fits exactly into the original theory of curved space. The implications lead to some stout philosophical interpretation, a matter which we would do well not to pursue *here.*

The author brings a rich heritage to the book. It was written on the invitation of Professor I. S. Sokolnikoff of U.C.L.A. and is thus one of The Applied Mathematics Series so ably edited by him.

Personally I would prefer a bit more "physics" in a text of this sort, but this is not to be construed as an adverse comment. After all, the physicist can inject his physics if his students have the mathematical equipment, for this, we are agreed, is the only adequate tool for acquiring complete understanding.

JULIUS SUMNER MILLER
Dillard University
New Orleans 22, Louisiana

AN INTRODUCTION TO THE MECHANICS OF VISCOUS FLOW, by H. P. F. Purday, *Chief Designer in the Higher Speed Diesel Engine Department of Harland and Wolff Limited.* 176 pages. 47 diagrams. First American Edition. Published in England under the title "Streamline Flow." Dover Publications, Inc. $2.75.

This monograph is a specialist's treatment of a highly technical array of applied mathematical physics. It introduces three aspects of applied physics, viz., mechanics of non-turbulent flow, the flow of heat by conduction, and heat transfer between solids and fluids in states of non-turbulent flow. The emphasis is divided into physics, mathematics, and technical application.

Although the mathematical background needed for pursuing this small volume is presumably only the calculus, the author introduces with glaring freedom Gamma functions, elliptic integrals, Bessel functions, orthogonal functions and other highly sophisticated mathematical tools.

The exposition is clear and a number of illustrative problems are worked out. Research workers and designers in streamline flow will find this monograph helpful. It would be a good exercise for advanced students pursuing a course like Sokolnikoff's Higher Mathematics for Engineers and Physicists.

A brief bibliography directs the reader to more complete materials on the subject.

Advanced graduate students contemplating work in aircraft industry or jet mechanisms would profit by a study of this treatment.

JULIUS SUMNER MILLER

ENCYCLOPEDIA ON CATHODE-RAY OSCILLOSCOPES AND THEIR USES, by John F. Rider and Seymour S. Uslan *of the John F. Rider Publishing Company.* Cloth. Pages vii+982, 21×27.5 cm. 1950. John F. Rider Publisher, Inc., 480 Canal Street, New York 13, N. Y. Price $9.00.

This volume consists of 22 chapters illustrated with some 3000 photographs and drawings and a complete index. It is divided into four sections covering the theory of operation of cathode ray tubes and their industrial and scientific applications. The first part of the book is devoted to a discussion of the fundamental theory of cathode ray tubes and oscilloscopes. The second part discusses their uses as measuring and testing instruments and their applications in receiver alignment, transmitter adjustment, and measurement of radio and audio frequency components in electronic circuits. The third part is devoted to an analysis of cathode ray tube circuits which includes descriptions of commercial oscilloscopes manufactured within the past decade together with the schematic diagrams of each. The last section contains drawings of 1600 wave patterns produced

by varying the harmonic content phase and amplitude. Three appendices giving the characteristics of cathode ray tubes, base diagrams and photographic data conclude the text. The book is well bound in cloth and printed in easy to read type in double spaced columns.

LOWELL C. WARNER
Wilson Junior College
Chicago, Ill.

TV INSTALLATION TECHNIQUES, by Samuel L. Marshall, *Television Instructor, George Westinghouse Vocational High School, New York City*. Cloth. 336 pages. 13.5×21 cm. 1950. John F. Rider Publisher, Inc., 480 Canal Street, New York 13, N. Y. Price $3.60.

This is a practical book written chiefly for those interested in television installation. The first three chapters are devoted to a general description of the characteristics of television, high frequency wave propagation and antennas. Transmission lines, matching networks, antenna arrays and methods of installation are discussed in chapters four and five. The following two chapters contain suggested procedures in the erection of masts and towers with methods of overcoming common difficulties encountered in typical installations. Receiver adjustment and service are the subjects of chapter eight. The last chapter contains many municipal regulations and underwriter codes covering TV installations. Channel frequencies, transmission line characteristics, physical and electrical constants of conductors and picture tube data are included in the appendix. The book is amply illustrated with good line drawings and photographs. Enough theory is included so that a non-academic reader can obtain a basic understanding and respect for the procedures and suggestions outlined in the text.

LOWELL C. WARNER

SMITH'S INTRODUCTORY COLLEGE CHEMISTRY, by William F. Ehret, *Professor of Chemistry, New York University*. Cloth. Pages viii+511. 17.5×25 cm. Third Edition. 1950. Appleton-Century-Crofts, Incorporated, New York, N. Y. Price $4.25.

This abbreviated counterpart of a distinguished college text (*Smith's College Chemistry*) has a long and honorable history of its own, for it has been in use since 1931. Because twelve years have elapsed since the second edition was published, rendering its treatment of certain topics seriously out of date, the new third edition is particularly welcome.

One expects an introductory text on general chemistry to be first of all extensive and clear; he does not demand that it be intensive in the development of its subjects—indeed, with the requirements of most first-year courses what they are, intensity of treatment may be a liability; and he hopes that it will be reasonably precise, particularly in the statement of the laws of chemistry and related science. Professor Ehret has met these criteria well. His text is extensive in its coverage of chemical laws, the elements, compounds and valences, and nuclear structure and reactions. Although it is necessarily brief in its discussions, it provides references to background and supplementary material (listed at the end of each chapter), and it offers numerous problems which the teacher may use to develop the capsulized quantitative concepts of the science to whatever degree he desires. It is particularly grafitying in the preciseness which it achieves generally without sacrifice of simplicity and clarity.

The arrangement of material is worthy of mention. The book is divided into forty-nine short chapters, the longest of seventeen pages, the average about ten. The twenty chapters devoted to laws and principles are desirably concentrated in the first half of the text, but they have interspersed among them a number of chapters on specific elements and compounds to permit examples illustrating the various laws to be drawn from material with which the student is already familiar.

The author's treatment of solutions, solubilities, electrolytes, and acid-base systems is admirable and provides an excellent background for quantitative chemistry. The discussion of atomic structure, nuclear chemistry, and the ultimate particles of the universe is up to date and complete (only the neutrino is omitted). Four chapters introduce the student briefly to the field of organic chemistry. In this reviewer's opinion, the book's greatest weakness lies in its development of the concept of chemical equilibrium, in that a clear distinction between equilibrium and rate of approach to it is not made; the careful teacher will need to clarify this point for his class.

Mechanically the book is excellent. The paper stock is good, the format is clear and attractive (two columns of text per page), and the illustrations are satisfactory. There are almost no typographical errors. The author is to be commended for his careful back-referencing of items discussed in earlier portions of the text and for his adoption of *Chemical Abstracts* nomenclature. This reviewer was bothered slightly by two practices: the omission of the period after the abbreviation of a unit (admittedly today's trend), and the placement of the chemical formula of a compound after its word-reference without parenthetical separation (example: "Sodium fluoride NaF is obtained . . . "). Neither of these is a profound defect.

This is a stimulating, accurate, and modern text worthy of serious consideration.

S. A. MILLER
University of Kansas

BUILD NEW ATOMIC "FURNACES" WITH RARE METAL, ZIRCONIUM

Zirconium, a metal that is most familiarly known in mixtures for the semi-precious gem stones, zircons, is being used in building our newest atomic "furnaces."

The Atomic Energy Commission would like to get this metal in ton lots for building atomic "ovens," but present production is only about 1,200 pounds per week. Even this is a big improvement, both in quantity and purity of the metal, over production before the metal had proved its worth as a structural material for atomic furnaces.

Only recently have methods for producing this metal in quantity been perfected. Melted zirconium, like titanium, its closest chemical relative, either reacts with or dissolves many of the usual materials used for melting vessels. Thus to separate it in pure form from the other ores with which it is found required great ingenuity for which American engineers can take credit.

The U. S. Bureau of Mines obtains the metal by reducing zirconium chloride with molten magnesium.

Highly resistant to many acids and with a melting point above 3400 degrees Fahrenheit, the metal would seem a natural for atomic pile use, but was not taken seriously because of the difficulty of handling it, separating it in a pure form.

Materials used in atomic furnaces cannot have any special liking for the neutrons that keep the chain reaction going. Steel, for instance, sops up neutrons although it is otherwise a good structural material. Zirconium, however, has a "low neutron capture cross section," as the liking for neutrons is called by the physicists, and it, or an alloy of it, is therefore being used for building atomic furnaces.

Convertible shoe with removable sole, recently patented, permits the owner to change from a light to heavy sole almost instantly. The shoe and the soles are manufactured separately. They are attached or separated easily by a special lock-device.

M.I.T. BUILDS SUPER DEEP-FREEZE

A 15-cubic-foot super deep-freeze, believed to be the world's largest very-low-temperature apparatus, which cools its contents to 452 degrees below zero Fahrenheit and can hold them there indefinitely, is now in operation at the Massachusetts Institute of Technology.

The largest, coldest box known—it will open the world of low-temperature research to studies on a scale never before possible.

Technically called a "cryostat," the new machine was designed and built by Dr. Samuel C. Collins, professor of mechanical engineering, in the M.I.T. low-temperature research laboratories with funds provided by the Navy Bureau of Ordnance and Office of Naval Research.

The new low-temperature machine, based largely on principles used by Professor Collins for the construction of a smaller cryostat of original design in 1946, operates by compressing, regeneratively cooling, and then expanding helium gas until a portion of the gas turns into a liquid just 7½ degrees above absolute zero, the lowest theoretically possible temperature.

The new machine, Professor Collins points out, fulfills for the first time the need for a large refrigerated space in which heavy equipment can be cooled and studied at lower temperatures than ever before possible. It provides a cylindrical working space 30 inches in diameter and three feet deep—larger than most home refrigerators—in which experiments may be operated and studied while held constantly at this low temperature.

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During the recent war Germany relied heavily on liquid fuels for aircraft and submarines. These products were obtained from coal and lignite. Russia today depends to a considerable extent on fuels from both coal and oil shale. American methods of obtaining liquid fuels from coal are based on German methods but are greatly improved.

The Louisiana plant is not designed for commercial production. It is an experimental laboratory to determine better ways of utilizing coal for this purpose. Commercial production awaits action by private industry, but the knowledge gained in this government establishment is available to private organizations.

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